

THE DIVERSITY OF FEATHERPRINTS IN THE CHARADRIIFORMES AND IN THE
ANSERIFORMES

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SUMMARY

Scanning electron microscopy pictures (called featherprints) of the feather surface, of 65 charadriiform species belonging to 31 genera and 13 families, were studied to shed some light on their diversity and on their identification value. We started our descriptions with the different aspects of the obverse rachis surface (site IX). Marked differences in the featherprint formulae of nearly all species could be observed except in the Three-banded Plover *Charadrius tricollaris* (F. Charadriidae) and the Redshank *Tringa totanus* (F. Scolopacidae). An identification key is presented. Sixteen anseriform species were examined similarly. Clear-cut differences were noticed between ducks, geese and swans.

Keywords: featherprints, SEM, Charadriiformes, Anseriformes

INTRODUCTION

Birds have been recognized as a potential hazard to safe operation of aircraft since the inception of the first aeroplane service (ICAO 1978). One of the first steps in reducing this risk is establishing which species are most likely to cause an accident. Only when a detailed insight regarding the species most frequently involved in bird strikes has been obtained, the most adequate preventive measures may be taken.

Apart from preliminary biochemical studies of blood and flesh remains (De Bont *et al.* 1986), attention has been focused on the identification of feathers and feather fragments (Brom 1980, 1986, 1991). The reason for this is that nearly always feather remains are present in the bird remains. Up till recently none of the morphological methods used in feather research was completely satisfactory. So I developed a new method. Studying the drawings on the rachis, rami and rachidial barbules of the feathers by means of a scanning electron microscope very promising results were obtained (Perremans 1990). The method has been successfully used for the identification of the birds involved in a series of bird strikes.

In this paper the submicroscopic characteristics, at a scanning electron microscope level, of 65 Charadriiformes and of 16 Anseriformes are described. Marked differences in featherprint formulae were noticed. A key is presented for the charadriiform species.

MATERIAL AND METHODS

I studied 65 charadriiform species belonging to 31 genera and 13 families and 16 anseriform species belonging to 12 genera and 1 family.

The following Charadriiformes were examined:

.Jacanidae: African Jacana *Actophilornis africana* (Gmelin, 1789); Wattled Jacana *Jacana jacana* (Linnaeus, 1766);

.Rostratulidae: Painted Snipe *Rostratula benghalensis* (Linnaeus, 1758);

.Haematopodidae: African Black Oystercatcher *Haematopus moquini* Bonaparte, 1856; Oystercatcher *Haematopus ostralegus* Linnaeus, 1758;

.Recurvirostridae: Black-winged Stilt *Himantopus himantopus* (Linnaeus, 1758);

.Burhinidae: Spotted Thick-Knee *Burhinus capensis* (Lichtenstein, 1823); Senegal Thick-Knee *Burhinus senegalensis* (Swainson, 1837); Water Thick-Knee *Burhinus vermiculatus* (Cabanis, 1868); Stone Curlew *Burhinus oedicnemus* (Linnaeus, 1758);

.Glareolidae: Egyptian Plover *Pluvianus aegypticus* (Linnaeus, 1758); Collared Pratincole *Glareola pratincola* (Linnaeus, 1766); Black-winged Pratincole *Glareola nordmanni* Fischer, 1842; Temminck's Courser *Cursorius temminckii* Swainson, 1822; Grey Pratincole *Glareola cinerea* Fraser, 1843; Rock Pratincole *Glareola nuchalis* Gray, 1849;

.Charadriidae: Lapwing *Vanellus vanellus* (Linnaeus, 1758); Three-banded Plover *Charadrius tricollaris* Vieillot, 1818; White-fronted Plover *Charadrius marginatus* Vieillot, 1818; Caspian Plover *Charadrius asiaticus* Pallas, 1773; Grey Plover *Pluvialis squatarola* (Linnaeus, 1758); Lesser Black-winged Lapwing *Vanellus lugubris* (Lesson, 1826); Crowned Lapwing *Vanellus coronatus* (Boddaert, 1783); Spur-winged Lapwing *Vanellus spinosus* (Linnaeus, 1758); African Wattled Lapwing *Vanellus senegallus* (Linnaeus, 1766); Brown-chested Lapwing *Vanellus superciliosus* (Reichenow, 1886); Long-toed Lapwing *Vanellus crassirostris*

(Hartlaub,
Ringed Plover
pequarius ?
Golden Plover
.Scolopacidae
Scolopax rupestris
Marsh Sandpiper
nebularia (Linnaeus,
Numenius phaeopus
Turnstone
(Linnaeus,
Little Stint
1764); Common
Tringa ochropus
Dunlin *Calidris alpina*
.Stercorariidae
.Laridae: Black-throated
Larus cirrocygnus
1823; Common Goldeneye
(Linnaeus, 1758)
.Sternidae:
hirundo lunata
(Temminck, 1822)
.Rynchopidae
.Alcidae: Raven
(Linnaeus, 1758)
The following
.Anatidae:
galericola
Gadwall *A. strepera*
Pintail *A. platycaeca*
Aythya ferina
1758). Goldeneye
albellus (Linnaeus,
Eyton, 1838,
erythrophthalma
Greylag Goose

An intraspecific
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different plover
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rachis between
distal (site
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encountered
press).

(Hartlaub, 1855); Ringed Plover *Charadrius hiaticula* Linnaeus, 1758; Little Ringed Plover *Charadrius dubius* Scopoli, 1786; Kittlitz's Plover *Charadrius pecuarius* Temminck, 1823; Forbes' Plover *Charadrius forbesi* (Shelley, 1883); Golden Plover *Pluvialis apricaria* (Linnaeus, 1758);
Scolopacidae: Black-tailed Godwit *Limosa limosa* (Linnaeus, 1758); Woodcock *Scolopax rusticola* Linnaeus, 1758; Snipe *Gallinago gallinago* (Linnaeus, 1758); Marsh Sandpiper *Tringa stagnatilis* (Bechstein, 1803); Greenshank *Tringa nebularia* (Gunnerus, 1767); Redshank *Tringa totanus* (Linnaeus, 1758); Whimbrel *Numenius phaeopus* (Linnaeus, 1758); Great Snipe *Gallinago media* (Latham, 1787); Turnstone *Arenaria interpres* (Linnaeus, 1758); Ruff *Philomachus pugnax* (Linnaeus, 1758); Curlew Sandpiper *Calidris ferruginea* (Pontoppidan, 1763); Little Stint *Calidris minuta* (Leisler, 1812); Sanderling *Calidris alba* (Pallas, 1764); Common Sandpiper *Actitis hypoleucos* Linnaeus, 1758; Green Sandpiper *Tringa ochropus* Linnaeus, 1758; Wood Sandpiper *Tringa glareola* Linnaeus, 1758; Dunlin *Calidris alpina* (Linnaeus, 1758);

Stercorariidae: Great Skua *Stercorarius skua* Brunnich, 1764;

Laridae: Black-headed Gull *Larus ridibundus* Linnaeus, 1766; Grey-headed Gull *Larus cirrocephalus* Vieillot, 1818; Kelp Gull *Larus dominicanus* Lichtenstein, 1823; Common Gull *Larus canus* Linnaeus, 1758; Kittiwake *Rissa tridactyla* (Linnaeus, 1758); Herring Gull *Larus argentatus* Pontoppidan, 1763;

Sternidae: Sandwich Tern *Sterna sandvicensis* Latham, 1787; Common Tern *Sterna hirundo* Linnaeus, 1758; White-winged Black Tern *Chlidonias leucopterus* (Temminck, 1815); Swift Tern *Sterna bergii* Lichtenstein, 1823;

Rynchopidae: African Skimmer *Rynchops flavirostris* Vieillot, 1816;

Alcidae: Razorbill *Alca torda* Linnaeus, 1758; Puffin *Fratercula arctica* (Linnaeus, 1758); Guillemot *Uria aalge* (Pontoppidan, 1763); Little Auk *Alle alle* (Linnaeus, 1758).

The following Anseriformes were examined:

Anatidae: Shelduck *Tadorna tadorna* (Linnaeus, 1758), Mandarin Aix *galericulata* (Linnaeus, 1758), Wigeon *Anas penelope* Linnaeus, 1758, Gadwall *A. strepera* Linnaeus, 1758, Mallard *A. platyrhynchos* Linnaeus, 1758, Pintail *A. acuta* Linnaeus, 1758, Shoveler *A. clypeata* Linnaeus, 1758, Pochard *Aythya ferina* (Linnaeus, 1758), Common Scoter *Melanitta nigra* (Linnaeus, 1758), Goldeneye *Bucephala clangula* (Linnaeus, 1758), Smew *Mergus albellus* (Linnaeus, 1758), White-backed Duck *Thalassornis leucotis* Eyton, 1838, Maccoa Duck *Oxyura maccoa* (Eyton, 1838), Southern Pochard *Netta erythrophthalma* (Wied, 1832), Mute Swan *Cygnus olor* (Gmelin, 1789), Greylag Goose *Anser anser* (Linnaeus, 1758).

An intraspecific study established that there are only very slight differences in the featherprints of feathers originating from different parts of the body (Perremans 1990, Perremans *et al.* in press). Therefore only the ninth primary was used in this SEM study.

Nine sites of a feather (Perremans 1990: Fig. 1 and 2) were described: the reverso-lateral surface of the rachis below the rami (site I), the same surface between the rami (site 2), the proximal (site 3) and the distal (site IV) surface of a ramus below the barbules, the reverse surface of the base of the rachidial barbules (site V), the obverso-lateral surface of the rachis between the rami (site 6), the proximal (site VII) and the distal (site VIII) surface of a ramus above the barbules and the obverse surface of the rachis (site IX). For a description of the encountered features see Perremans (1990) and Perremans *et al.* (in press).

RESULTS

First the results of the Charadriiformes will be treated. I have found four different features (deep pits (DP), very small pits (VSP), relatively smooth (RS) and honey comb structure (HC)) on site IX. Cell boundaries are of type 1 (fine, deep laying lines) or type 6 (no cell boundaries visible). The cell surface is flat in all the examined species.

Two features are limited to one species: a relatively smooth (RS) obverse rachis surface is found in the Spotted Thick-Knee *Burhinus capensis* and a honey comb (HC) structure is found in the African Skimmer *Rynchops flavirostris*.

There are very small pits (VSP) at site IX in 19 species. Six of these species show cell boundaries of type 6 (Table 1). All species are recognizable by differences at other sites. Eleven of these species show cell boundaries of type 1 (Table 2). The species are recognizable by differences at other sites (Table 2). The two species (African Jacana *Actophilornis africana* and Swift Tern *Sterna bergii*) whose type of cell boundary at site IX is unknown differ as well from all the species of Table 1 as from all the species of Table 2.

The remaining species (n = 44) possess deep pits (DP) at site IX. Ten of these species show cell boundaries of type 6 (Table 3). All formulae of Table 3 are different. The remaining 34 species show cell boundaries of type 1 (Table 4). All the featherprint formulae of Table 4 are different except those of the Three-banded Plover *Charadrius tricollaris*, the Long-toed Lapwing *Vanellus crassirostris* (both Charadriidae) and the Redshank *Tringa totanus* (Scolopacidae). The formula from the Long-toed Lapwing differs from the two others in the type of cell boundary.

In the Anseriformes all ducks (n=14) show a finely frayed surface with cell boundaries of type 5 (Fig. 1a, b) on site I, II, III, IV, VI and VII, the Greylag Goose and the Mute Swan show a completely different picture. In the two last species micropapillae are encountered on the reverse surface of the rachis. The goose and the swan differ from each other in the concentration of these micropapillae and in the type of cell boundary (Fig 1c, d).

DISCUSSION

I wanted to shed some light on the diversity of featherprints in the Charadriiformes and on their value as identification clues. The featherprint formulae of all examined species (n=65) with the exception of those of the Three-banded Plover *Charadrius tricollaris* (F. Charadriidae) and the Redshank *Tringa totanus* (F. Scolopacidae) showed marked differences.

This method together with the method of Brom (1980, 1986, 1991) offers the best possibilities when interested in bird identification starting from feathers or feather remains. The morphological studies of other authors (Gladstone 1918, Auber and Appleyard 1951, Auber 1955, 1957, Auber and Mason 1955, Rutschke

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IDENTIFICATION

The key wil charadriiform obtained obse K.U.Leuven). feather remai

1. Site IX r
Site IX h
Site IX v
Site IX d
2. VSP with
VSP with
3. Site I ve
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Site I mi
Site I mi
4. Site II fi
Site II ve

1960, 1966, Day 1966, Dyck 1971, 1973, 1990, Swales 1970, Lyster 1985, Horton 1990) are too fragmentary to be valid for an identification. When identifying bird remains from strikes it is impossible to use biochemical methods (such as electrophoresis: Ouellet and van Zyll de Jong 1990) because one never knows which changes your proteins have gone through. Also the analysis of keratin is unreliable because the relative amounts of amino acids vary among the calamus, barbs, and the cortex and the medulla of the rachis (Harrap and Woods 1964, 1967).

Until recently no large differences in feather structure between ducks, geese and swans (Anatidae, Anseriformes) could be detected (Chandler 1916, Brom 1980, Horton 1990). The number of terminal barbule nodes in downy barbules of Anatidae may vary considerably (1 to 10) according to Chandler (1916). This, however, is of no diagnostic value since large differences may be found, for this character, between feathers of the same bird (Brom 1980). Also, Brom (1980) did not find significant differences in the length of the downy barbules of various species of Anatidae. When measuring the part of the downy barbules that show heart-shaped nodes he found a difference, but not strictly delimited, between ducks, geese and swans. The genus Tadorna showed lengths intermediate between ducks and geese. Horton (1990) could separate ducks from geese and swans using three measurements (base length BL, node width NW and internode length INL) on basal downy barbules of basal barbs taken from breast feathers of a number of anseriform species. A further separation was less successful.

In the preliminary SEM study, on the surface structures of the Anatidae, Anseriformes, clear-cut differences between ducks (n=14), a goose (n=1) and a swan (n=1) were discovered.

IDENTIFICATION KEY

The key will only permit identification of the 65 examined charadriiform species. It is strongly recommended to compare the obtained observations with a reference library (existing at the K.U.Leuven). The key can only be adopted for identification of feather remains when rachis parts are present.

1. Site IX relatively smooth.....Spotted Thick-Knee
 Site IX honey comb structure.....African Skimmer
 Site IX very small pits.....2
 Site IX deep pits.....10
2. VSP with cell boundaries of type 6.....3
 VSP with cell boundaries of type 1.....5
3. Site I very roughly frayed.....Oystercatcher
 Site I finely frayed.....Temminck's Courser
 Site I micropapillae of density b.....Stone Curlew
 Site I micropapillae of density d.....Collared Pratincole
 Site I micropapillae of density f.....4
4. Site II finely frayed.....Egyptian Plover
 Site II very roughly frayed.....Golden Plover

5. Site I very roughly frayed in the presence of a few micropapillae.....Kittiwake
 Site I very roughly frayed.....Herring Gull
 Site I roughly frayed.....Razorbill
 Site I finely frayed.....9
 Site I micropapillae of density b.....7
 Site I micropapillae of density d.....6
6. Site III roughly frayed.....Black-tailed Godwit
 Site III finely frayed.....Common Tern
7. Site VI roughly frayed.....Senegal Thick-Knee
 Site VI micropapillae of density d.....8
8. Site VII very roughly frayed.....Whimbrel
 Site VII roughly frayed.....Snipe
9. Site II finely frayed.....Great Skua
 Site II roughly frayed.....Ruff
 Site II very roughly frayed.....Greenshank
10. DP with cell boundaries of type 6.....11
 DP with cell boundaries of type 1.....17
11. Site I very roughly frayed.....Common Gull
 Site I finely frayed.....12
 Site I micropapillae of density b.....Great Snipe
 Site I micropapillae of density c.....15
 Site I micropapillae of density d.....16
12. Site II finely frayed.....Wattled Jacana
 Site II roughly frayed.....13
13. Site IV very roughly frayed.....Dunlin
 Site IV roughly frayed.....14
14. Site VI very roughly frayed.....Green Sandpiper
 Site VI roughly frayed.....Common Sandpiper
15. Site II roughly frayed in the presence of a few micropapillae.....Black-winged Pratincole
 Site II micropapillae of density c.....Woodcock
16. Site II very roughly frayed.....Brown-chested Lapwing
 Site II roughly frayed.....Lapwing
17. Site I roughly frayed in the presence of a few micropapillae.....Caspian Plover
 Site I very roughly frayed.....Little Auk
 Site I roughly frayed.....18
 Site I finely frayed.....21
 Site I micropapillae of density b.....33
 Site I micropapillae of density c.....34
 Site I micropapillae of density d.....35
 Site I micropapillae of density f.....36
18. Site III very roughly frayed.....Kelp Gull
 Site III roughly frayed.....19
19. Site VI roughly frayed.....Puffin
 Site VI very roughly frayed.....20
20. Site VII very roughly frayed.....Little Stint
 Site VII roughly frayed.....Kittlitz's Plover
21. Site II very roughly frayed.....22
 Site II roughly frayed.....26
22. Site III very roughly frayed.....Turnstone
 Site III roughly frayed.....23
23. Site IV very roughly frayed.....Wood Sandpiper
 Site IV roughly frayed.....24
24. Site VI roughly frayed.....Marsh Sandpiper
 Site VI very roughly frayed.....25

25. Site V
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LITERATURE C

Auber, L. 1961
 Auber, L. 1962

25. Site VIII very roughly frayed.....Grey Plover
 Site VIII roughly frayed.....Sanderling
26. Site III very roughly frayed.....White-winged Black Tern
 Site III roughly frayed.....28
 Site III finely frayed.....27
27. Site IV roughly frayed.....Curlew Sandpiper
 Site IV finely frayed.....Sandwich Tern
28. Site IV finely frayed.....Ringed Plover
 Site IV very roughly frayed.....29
 Site IV roughly frayed.....30
29. Site VII very roughly frayed.....White-fronted Plover
 Site VII roughly frayed.....Guillemot
30. Site VI finely frayed.....Painted Snipe
 Site VI roughly frayed.....31
31. Site VIII roughly frayed.....Forbes' Plover
 Site VIII finely frayed.....32
32. Site VI roughly frayed with cell
 boundaries of type 6.....Long-toed Lapwing
 Site VI roughly frayed with cell
 boundaries of type 3.....Redshank and
 Three-banded Plover
33. Site II very roughly frayed in the
 presence of a few micropapillae.....Black-headed Gull
 Site II roughly frayed in the
 presence of a few micropapillae.....Grey-headed Gull
 Site II micropapillae of density b.....Water Thick-Knee
34. Site II very roughly frayed in the
 presence of a few micropapillae.....Black-winged Stilt
 Site II very roughly frayed.....Lesser Black-winged
 Lapwing
 Site II roughly frayed.....African Wattled Lapwing
 Site II micropapillae of density d.....African Black
 Oystercatcher
35. Site II very roughly frayed.....Crowned Lapwing
 Site II finely frayed.....Rock Pratincole
36. Site II roughly frayed.....37
 Site II finely frayed.....Spur-winged Lapwing
37. Site VI roughly frayed.....Little Ringed Plover
 Site VI finely frayed.....Grey Pratincole

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TABLE 1. Featherprint formulae of birds where site IX has very small pits and cell boundaries of type 6; FF=finely frayed, RF=roughly frayed, VRF=very roughly frayed, b, d, and f=micropapillae with concentrations b, d and f.

species	site	I	II	III	IV	V	VI	VII	VIII
Oystercatcher <i>Haematopus ostralegus</i>		VRF	VRF	VRF	RF	FF	VRF	VRF	VRF
Stone Curlew <i>Burhinus oedicephalus</i>		b	b	b	b	FF	FF	d	FF
Collared Pratincole <i>Glareola pratincola</i>		d	VRF	VRF	RF	FF	RF	FF	FF
Temminck's Courser <i>Cursorius temminckii</i>		FF	FF	FF	RF	FF	FF	FF	FF
Egyptian Plover <i>Pluvianus aegypticus</i>		f	FF	FF	FF	FF	FF	FF	FF
Golden Plover <i>Pluvialis apricaria</i>		f	VRF	VRF	VRF	FF	VRF	VRF	VRF

TABLE 2. Featherprint formulae of birds where site IX has very small pits and cell boundaries of type 1; VRF+M=very roughly frayed in the presence of a few micropapillae; for symbols see Table 1.

species	site	I	II	III	IV	V	VI	VII	VIII
Senegal Thick-Knee <i>Burhinus senegalensis</i>		b	b	b	b	FF	RF	FF	FF
Greenshank <i>Tringa nebularia</i>		FF	VRF	FF	RF	FF	VRF	FF	FF
Whimbrel <i>Numenius phaeopus</i>		b	b	b	b	FF	d	VRF	VRF
Snipe <i>Gallinago gallinago</i>		b	b	b	b	FF	d	RF	RF
Ruff <i>Philomachus pugnax</i>		FF	RF	RF	FF	FF	RF	FF	FF
Black-tailed Godwit <i>Limosa limosa</i>		d	RF	RF	RF	FF	RF	RF	RF
Great Skua <i>Stercorarius skua</i>		FF	FF	VRF	RF	FF	RF	RF	RF

Herring Gull <i>Larus argentatus</i>
Kittiwake <i>Rissa tridactyla</i>
Common Tern <i>Sterna hirundo</i>
Razorbill <i>Alca torda</i>

TABLE 3. Featherprint formulae of birds where site IX has very small pits and cell boundaries of type 1; VRF+M=very roughly frayed in the presence of a few micropapillae; for symbols see Table 1.

species	site
Wattled Jacana <i>Jacana jacana</i>	
Black-winged Pratincole <i>Glareola nordmanni</i>	
Brown-chested Lapwing <i>Vanellus superciliosus</i>	
Lapwing <i>Vanellus vanellus</i>	
Green Sandpiper <i>Tringa ochropus</i>	
Great Snipe <i>Gallinago media</i>	
Dunlin <i>Calidris alpina</i>	
Common Sandpiper <i>Actitis hypoleucos</i>	
Woodcock <i>Scolopax rusticola</i>	
Common Gull <i>Larus canus</i>	

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Herring Gull <i>Larus argentatus</i>	VRF	VRF	VRF	VRF	FF	VRF	VRF	RF
Kittiwake <i>Rissa tridactyla</i>	VRF+M	VRF	VRF	VRF	FF	VRF	VRF	VRF
Common Tern <i>Sterna hirundo</i>	d	RF	FF	FF	FF	VRF	RF	FF
Razorbill <i>Alca torda</i>	RF	RF	RF	RF	FF	VRF	VRF	RF

TABLE 3. Featherprint formulae where site IX has deep pits and cell boundaries of type 6 with c=micropapillae with concentration c, RF+M=roughly frayed in the presence of a few micropapillae; for symbols see Table 1.

species	site	I	II	III	IV	V	VI	VII	VIII
Wattled Jacana <i>Jacana jacana</i>		FF	FF	FF	FF	FF	FF	FF	FF
Black-winged Pratincole <i>Glareola nordmanni</i>	c	RF+M	RF	RF	RF	FF	RF	RF	FF
Brown-chested Lapwing <i>Vanellus superciliosus</i>	d	VRF	d	RF	RF	FF	RF	RF	VRF
Lapwing <i>Vanellus vanellus</i>	d	RF	RF	RF	RF	FF	RF	RF	FF
Green Sandpiper <i>Tringa ochropus</i>		FF	RF	RF	RF	FF	VRF	VRF	FF
Great Snipe <i>Gallinago media</i>		b	b	b	b	FF	f	RF	FF
Dunlin <i>Calidris alpina</i>		FF	RF	RF	VRF	FF	VRF	VRF	FF
Common Sandpiper <i>Actitis hypoleucos</i>		FF	RF	RF	RF	FF	RF	RF	FF
Woodcock <i>Scolopax rusticola</i>		c	c	c	c	FF	RF	RF	RF
Common Gull <i>Larus canus</i>		VRF	VRF	VRF	RF	FF	VRF	VRF	RF

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TABLE 4. Featherprint formulae of birds where site IX has deep pits and cell boundaries of type 1 with 3 or 6=cell boundaries of type 3 (thick, rising lines) or of type 6 (no cell boundaries visible); for symbols see Table 1.

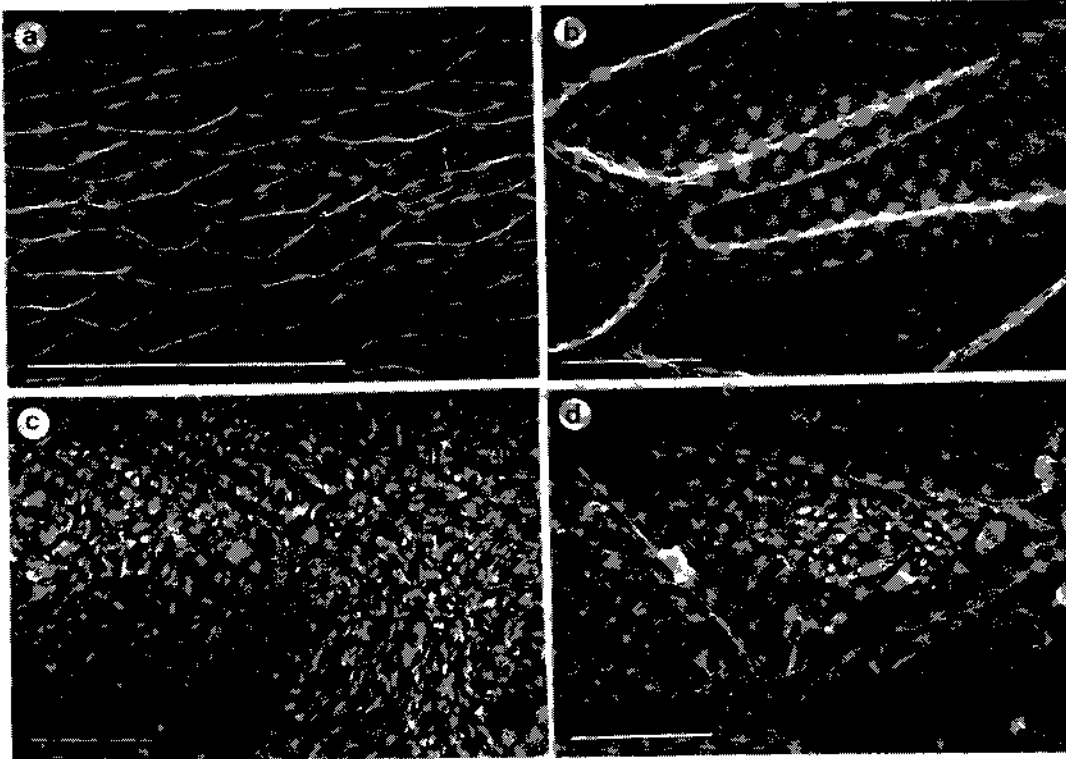
species	site	I	II	III	IV	V	VI	VII	VIII
Painted Snipe <i>Rostratula benghalensis</i>		FF	RF	RF	RF	FF	FF	FF	FF
African Black Oystercatcher <i>Haematopus moquini</i>		c	d	d	c	FF	RF	RF	VRF
Black-winged Stilt <i>Himantopus himantopus</i>		c	VRF+M	VRF+M	VRF+M	FF	RF	VRF	FF
Water Thick-Knee <i>Burhinus vermiculatus</i>		b	b	b	b	FF	FF	FF	FF
Grey Pratincole <i>Glareola cinerea</i>		f	RF	RF	RF	FF	FF	FF	FF
Rock Pratincole <i>Glareola nuchalis</i>		d	FF	FF	FF	FF	RF	FF	FF
Three-banded Plover <i>Charadrius tricollaris</i>		FF3	RF3	RF3	RF3	FF6	RF3	RF3	FF6
White-fronted Plover <i>Charadrius marginatus</i>		FF	RF	RF	VRF	FF	VRF	VRF	FF
Caspian Plover <i>Charadrius asiaticus</i>		RF+M	RF	RF	RF	FF	VRF	RF	FF
Ringed Plover <i>Charadrius hiaticula</i>		FF	RF	RF	FF	FF	VRF	VRF	RF
Little Ringed Plover <i>Charadrius dubius</i>		f	RF	RF	RF	FF	RF	RF	FF
Kittlitz's Plover <i>Charadrius pecuarius</i>		RF	RF	RF	RF	FF	VRF	RF	VRF
Forbes' Plover <i>Charadrius forbesi</i>		FF	RF	RF	RF	FF	RF	RF	RF
Grey Plover <i>Pluvialis squatarola</i>		FF	VRF	RF	RF	FF	VRF	VRF	VRF
Lesser Black-winged Lapwing <i>Vanellus lugubris</i>		c	VRF	RF	RF	FF	VRF	VRF	FF
Crowned Lapwing <i>Vanellus coronatus</i>		d	VRF	VRF	RF	FF	VRF	VRF	VRF

Spur-wing <i>Vanellus</i>
African W <i>Vanellus</i>
Long-toed <i>Vanellus</i>
Marsh San <i>Tringa st</i>
Redshank <i>Tringa to</i>
Wood Sand <i>Tringa gl</i>
Turnstone <i>Arenaria</i>
Curlew San <i>Calidris</i>
Little St <i>Calidris</i>
Sanderling <i>Calidris</i>
Grey-head <i>Larus cirr</i>
Kelp Gull <i>Larus domi</i>
Black-head <i>Larus ridi</i>
Sandwich T <i>Sterna san</i>
White-wing <i>Chlidonias</i>
Guillemot <i>Uria aalge</i>
Little Auk <i>Alle alle</i>
Puffin <i>Fratercula</i>

Spur-winged Lapwing <i>Vanellus spinosus</i>	f	FF	f	FF	FF	RF	RF	RF
African Wattled Lapwing <i>Vanellus senegallus</i>	c	RF	d	RF	FF	RF	RF	FF
Long-toed Lapwing <i>Vanellus crassirostris</i>	FF3	RF3	RF3	RF3	FF6	RF6	RF3	FF6
Marsh Sandpiper <i>Tringa stagnatilis</i>	FF	VRF	RF	RF	FF	RF	RF	FF
Redshank <i>Tringa totanus</i>	FF3	RF3	RF3	RF3	FF6	RF3	RF3	FF6
Wood Sandpiper <i>Tringa glareola</i>	FF	VRF	RF	VRF	FF	VRF	VRF	FF
Turnstone <i>Arenaria interpres</i>	FF	VRF	VRF	RF	FF	VRF	VRF	VRF
Curlew Sandpiper <i>Calidris ferruginea</i>	FF	RF	FF	RF	FF	RF	RF	FF
Little Stint <i>Calidris minuta</i>	RF	RF	RF	RF	FF	VRF	VRF	FF
Sanderling <i>Calidris alba</i>	FF	VRF	RF	RF	FF	VRF	VRF	RF
Grey-headed Gull <i>Larus cirrocephalus</i>	b	RF+M	RF+M	RF	FF	VRF	VRF	FF
Kelp Gull <i>Larus dominicanus</i>	RF	RF	VRF	VRF	FF	RF	VRF	VRF
Black-headed Gull <i>Larus ridibundus</i>	b	VRF+M	VRF+M	VRF+M	FF	VRF	VRF	FF
Sandwich Tern <i>Sterna sandvicensis</i>	FF	RF	FF	FF	FF	FF	FF	FF
White-winged Black Tern <i>Chlidonias leucopterus</i>	FF	RF	VRF	VRF	FF	VRF	VRF	FF
Guillemot <i>Uria aalge</i>	FF	RF	RF	VRF	FF	VRF	RF	FF
Little Auk <i>Alle alle</i>	VRF	VRF	VRF	VRF	FF	VRF	VRF	FF
Puffin <i>Fratercula arctica</i>	RF	RF	RF	RF	FF	RF	RF	RF

FIGURE 1.a: Southern Pochard: site I finely frayed with cell boundaries of type 5. Bar=100 μ m; b: Southern Pochard: site I more in detail. Bar=10 μ m; c: Greylag Goose: site I micropapillae of density b with cell boundaries of type 1. Bar=10 μ m; d: Mute Swan: site I micropapillae of density c with cell boundaries of type 5. Bar=10 μ m.

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