Identifying Individual Great Gray Owls (*Strix nebulosa*) and Snowy Owls (*Bubo scandiacus*) Using Wing Feather Bar Patterns

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IDENTIFYING INDIVIDUAL GREAT GRAY OWLS (*STRIX NEBULOSA*) AND SNOWY OWLS (*BUBO SCANDIACUS*) USING WING FEATHER BAR PATTERNS

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Abstract.—Bar patterns on flight feathers of Great Gray Owls (*Strix nebulosa*) and Snowy Owls (*Bubo scandiacus*) are variable, and can be used to recognize individual birds. Here I illustrate a method for taking photos of wings of captured owls and describe a way to arrange images of flying birds for comparison with photos of birds in flight or in the hand. I report four examples. First, two Great Gray Owls photographed in flight on different days at the same site were shown to be the same individual, but differed from a dead owl found at that location a month later. Second, I compared eight photographs of wintering Snowy Owls in flight in Saskatchewan and determined that they portrayed seven different owls. Third, I examined photos of breeding male first-year Great Gray Owls at neighboring nest sites and established that they were different birds. Finally, I compared photos of breeding female Great Gray Owls at the same nest site in 2011 and 2013, and determined that they showed two individuals. I suggest that such photography may be used as a tool to census populations of Great Gray Owls and Snowy Owls.

Key Words: *Great Gray Owl*; Strix nebulosa; *Snowy Owl*; Bubo scandiacus; *digital photography*; *individual identification*; *plumage*.

IDENTIFICACIÓN DE INDIVIDUOS DE *STRIX NEBULOSA* Y *BUBO SCANDIACUS* UTILIZANDO LOS PATRONES DE BARRAS DE LAS PLUMAS DEL ALA

Resumen.—Los patrones de barras de las plumas de vuelo de *Strix nebulosa* y *Bubo scandiacus* son variables y pueden ser utilizados para reconocer aves individualmente. En este trabajo, presento un método de toma de fotografías de las alas de los búhos capturados y describo una manera de organizar las imágenes de las aves en vuelo para compararlas con las fotos de aves en vuelo o capturadas, por medio de cuatro ejemplos. Primero, dos individuos de *S. nebulosa* fotografiados en vuelo en diferentes días en el mismo sitio demostraron ser el mismo individuo, pero difirieron de un búho muerto encontrado en esa ubicación un mes después. Segundo, comparé ocho fotografías de individuos invernantes de *B. scandiacus* en vuelo en Saskatchewan y determiné que correspondían a siete búhos diferentes. Tercero, examiné fotos de un macho reproductivo del primer año de *S. nebulosa* en lugares de nidificación vecinos y comprobé que eran aves diferentes. Finalmente, comparé fotos de una hembra reproductora de *S. nebulosa* en el mismo lugar de nidificación en 2011 y 2013 y determiné que pertenecían a dos individuos. Sugiero que este tipo de fotografías pueden ser utilizados como una herramienta para censar poblaciones de *S. nebulosa* y *B. scandiacus*.

[Traducción del equipo editorial]

Large mammals that are easily detected and observed in the wild have long been individually identified based on unique physical traits. For example, individuals can be identified by facial differences among chimpanzees (*Pan troglodytes*; van Lawick-Goodall 1971) and gorillas (*Gorilla gorilla*; Schaller 1963, Fossey 1983) as easily as among humans. Physical traits were used to distinguish individual lions (*Panthera leo*; Schaller 1972) and other big cats, sea lions (Osterrieder et al. 2015), elephants (*Loxodonta* sp.; Douglas-Hamilton and Douglas-Hamilton 1975, Moss 1988) and whales (for which notches and color patterns on fins and tails are diagnostic; Hamilton et al. 2007). Similarly,

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Scott (1966) noted that the pattern of yellow and black on the bills of Tundra Swans (*Cygnus columbianus*) was highly variable, and could serve as a clue to individual recognition. Whooper Swans (*Cygnus cygnus*), on the other hand, were not as variable as Tundra Swans, making individual recognition more difficult for this species (Brazil 1981).

Frequent encounters and familiarity with a group of birds may enhance the ability to recognize individuals by plumage, but often such recognition based on physical differences is imperfect (McLaren 1975, Harper 1982). For example, in Norway, black belly notches have been used to recognize individual Lesser White-fronted Geese (*Anser erythropus*) at a staging ground (I. Øien pers. comm), but the method is not definitive because feather patterns change from spring to autumn. Thus, only geese with very extreme patterns can be recognized from one year to the next. Because of such challenges, individual recognition of birds in the field based on plumage characters has not been applied on a larger scale to date. Based on studies of the molt patterns of Great Gray Owls (*Strix nebulosa*; Solheim 2011) and Snowy Owls (*Bubo scandiacus*; Solheim 2012), and field studies on both (Solheim et al. 2008, Jacobsen et al. 2009, Solheim 2010, Berg et al. 2011, Solheim 2012, 2013), I have used modern digital photography and bar patterns on flight feathers as a tool to recognize individual birds of these two species. Here, I describe how to photograph captured and free-ranging owls, and how to distinguish differences in the size, shape, and color of wing feather bars. I present four examples in which this method was used to identify individuals based on photographs taken of birds in the wild.

METHODS

Photography Equipment. Any digital camera can be used to photograph birds in the hand provided it can capture the length of the entire wing on the image. I used a 35–50 mm lens and typically photographed the wing with a contrasting background (dark for Snowy Owls, light for Great Gray Owls). When possible, I avoided using a flash because it can distort the color contrasts between new and old feathers. When photographing owls, I used Canon D7 and D7 MkII cameras, with a Canon 500 mm 4.0 L IS USM lens (and sometimes a Canon 1.4 extender) or Canon 100–400 IS USM lens. For this type of photography, I prefer cameras that allow high ISO values, because shutter speeds of 1/1000 sec or faster should be used in dim light. Cameras should have at least 20 mega-pixels to allow cropping images of owls photographed at long ranges. Many modern cameras of several brands also have GPS units, allowing each image to be stored with exact location data.

I typically photographed owls in RAW mode for the best opportunity to enhance images shot in dim light. I digitally enhanced most photos to give the best comparison of feather barring among individual owls. I used Photoshop CS5 and CS6 software programs to enhance sharpness and contrast.

Taking Images of Captured Birds. When I captured an owl, I photographed each wing to show all primaries and secondaries and their bar patterns. This was preferably done with another researcher, so that one person held the owl and stretched out its wings one at a time while the other photographed. The primaries were well extended and the feathers arranged so they were all straight and showed the respective upper parts of the outer vanes (Fig. 1). The outermost primaries P9 and P10 were easily covered by the longer P8 and P7, so great care was taken to spread out these outer primaries. Birds as large as Snowy and Great Gray owls often tilted so the lower end (edge) of a wing bent away from the photographer; however, I took photos perpendicular to the wing plane (Fig. 2).

When photographing without help, I placed the bird at ground level and pulled out one wing at a time onto the ground. While holding the bird's feet with one hand, I used the other to operate a compact camera. However, this was not easy and rarely provided optimal images. As an alternative, I sometimes placed the camera on a tripod, set the shutter at 10-sec delay, and held the bird with one outstretched wing in front of the camera.

Taking Images of Flying Birds. Because free-ranging birds were photographed opportunistically, it was impossible for me to take images from the same angle at all times, as when photographing a bird in the hand. Even with the most advanced camera, it was challenging to photograph the upper wing surface of a flying owl to match against wing photos in a databank. However, I found that images of the underside of the wing sometimes also worked well, when light from above shone through the wing and made it possible to see barring from the underside of the feathers (Fig. 8, 10). However, underside images presented a smaller area of the wing for comparison than upper-side images, as only the part of flight feathers not overlapping with neighboring feathers showed clear views of the

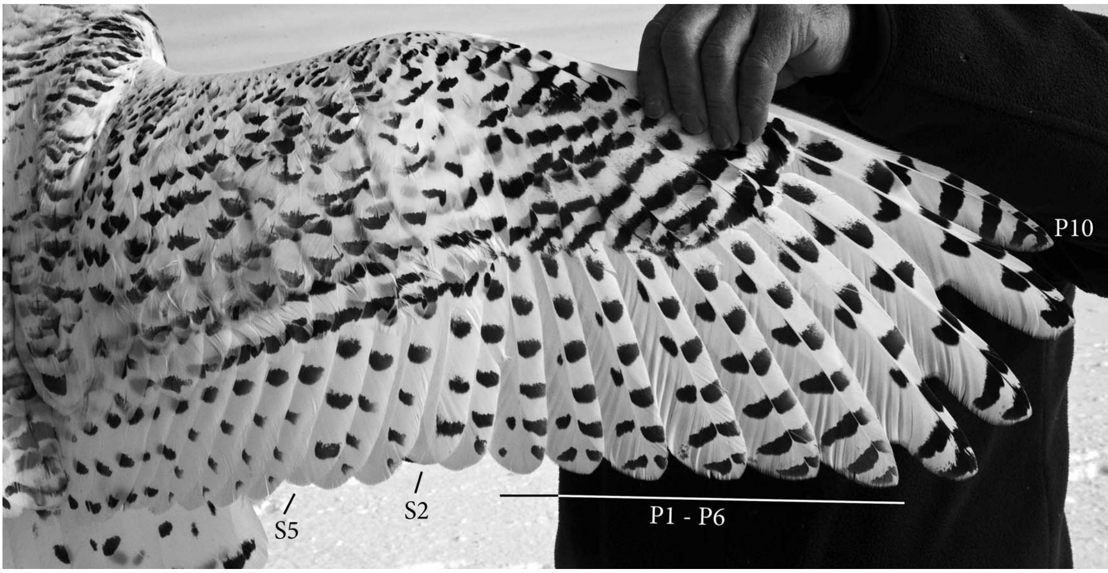

Figure 1. Wing of female Snowy Owl stretched out with outer vane of both primaries and secondaries visible. Primaries P1–P6 and P10, and secondaries S1, S3–S4, and S6–S9 are juvenile. Note that the dark bars on the inner vane are longer on juvenile than on adult primaries. Note also how the outer bars on P7 connect in a zig-zag pattern toward the rachis as opposed to the outer bars on juvenile feathers P5 and P6. On juvenile secondaries, there are (at least) four dark bars visible on the outer vane, whereas on the adult secondaries only three bars can be seen.

barring patterns. On an upper-side view, crossbar patterns showed clearly on the outer vane of each flight feather, although each overlapped with inner vanes of neighboring feathers.

The best opportunity for taking a good photo of the wing pattern of a flying owl was when the owl passed above me. These opportunities were infrequent for the wary Snowy Owl, but more common for the bolder Great Gray Owl, which sometimes flew directly overhead or approached closely to protect its nest or offspring. I shot images at the greatest number of frames per second as owls flew overhead, to maximize the opportunity to produce some usable images.

Comparing Patterns of Barring on Wing Feathers. The primaries usually gave the best opportunities for comparing bar patterns, but the secondaries sometimes added useful information. In both feather tracts, it was helpful to distinguish the pattern of old and new feathers based on the molt generations (Fig. 1). Birds in their first year (first calendar year autumn and second calendar year spring), before their first wing feather molt, did not have feathers of varying color and wear. Both owl species started their first wing molt with the innermost secondaries, and one to three of the longest primaries (Solheim 2011, 2012). After this stage, wings usually displayed feathers of different age and wear. The order of new and old wing feathers was helpful for recognizing an individual bird, and sometimes helped to separate individuals within the same molt cycle (from autumn year X to spring year X+1).

When I compared an image of the underside of a wing with an upper-side image of the same wing from another bird or situation, I used Photoshop to mirror one of the images for easier comparison of the patterns of the dark spots and bars on the

Figure 2. Owl wing being photographed in the correct manner.

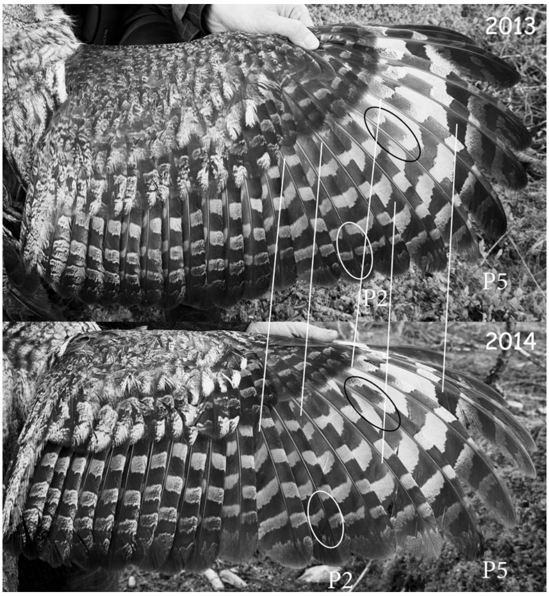

Figure 3. Right wing of female Great Gray Owl banded on 18 June 2013 and recaptured on 27 May 2014. Primaries P2 and P5 were molted during summer 2013. Circles outline where differences in bar patterns in this case are most easily seen. Note differences in how bars on outer and inner vane connect toward the rachis. Feathers not molted are linked with lines. Note that the image from 2014 is not optimal, because bar patterns of the outer primaries P8–P10 cannot be seen properly.

feathers. To separate individuals, I needed only a single difference in the bar pattern on one feather. To conclude that two images portrayed the same individual, I matched up at least several bar patterns on more than one feather, especially those markings of an unusual size or shape. I looked for clues, such as the thickness of bars, distance between bars, the form of the edge of a dark bar toward light areas, and differences in how bars from the outer and inner vanes aligned toward the rachis. Within one molt cycle (from autumn year X to spring year X+1), each individual had the same bar pattern, and any feather in a wing image could be compared with the same feather of a different wing image. Because each wing feather is retained for 2–4 yr in Snowy or Great Gray owls before it is molted (R. Solheim, unpubl. data), it was sometimes possible for me to recognize an individual from year X up to year X+3 or in rare cases up to year X+4. Fresh feathers in year X were compared with worn feathers in the same position in a later year (see Fig. 3).

Results

I photographed and compared bar patterns of Great Gray Owls at the same locality on different dates, female Snowy Owls on wintering grounds, subadult Great Gray Owl males at neighboring nest sites, and female Great Gray Owls at the same nest site over a 2-yr period. Below, I describe how I used wing photography to answer questions about individual owl identities in the field.

Figure 4. Great Gray Owl photographed on different dates by H. Sørhuus (left) and T. Kolaas (right) in Levanger, North Trøndelag, Norway, April 2009. The first clue to similarities of these two images is the difference in molt on the left and right wings. On the left wing, only P5 is a non-juvenile primary, while on the right wing the three primaries P4–P6 have been molted. The rest of the primaries have light tips and a narrow, outer dark bar, diagnostic of juvenile flight feathers on Great Gray Owls (Solheim 2011).

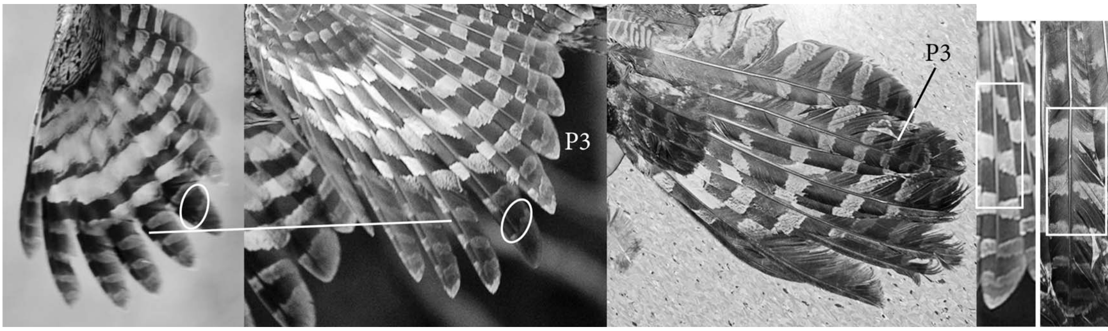

Figure 5. Primaries of the left wings of the two flying birds from Figure 4, and the wing of a Great Gray Owl found dead in Levanger, 20 May 2009. On the wing images, the most striking similarities are the outer edge on the dark bar on the inner vane of P5 (white circle), and the pattern of bars toward the rachis on P6 (white line). The bar edges are also similar. Primary P3 from the live (left) and dead (right) birds are aligned for easier comparison at right. The bar section that differs the most is outlined.

Great Gray Owls at the Same Locality on Different Dates. In mid-central Norway, two researchers/photographers shot images of flying Great Gray Owls at different dates during April 2009 (Fig. 4). Both images of the flying owls showed P5 on the left wing was a dark, adult feather, whereas the other primaries were juvenile; thus, both images were of owls after the first wing feather molt. The molt was asymmetric, with the three primaries P4–P6 molted on the right wing. The asymmetry suggested that the images might show the same individual. By mirroring the left wing primaries on the bird flying toward the photographer, I easily compared the bar patterns of the primaries. Shape and alignment of the bars on several of the primaries showed that these images portrayed the same individual (Fig. 5). On 20 May 2009, a Great Gray Owl was found dead in the same region and brought to the Natural History

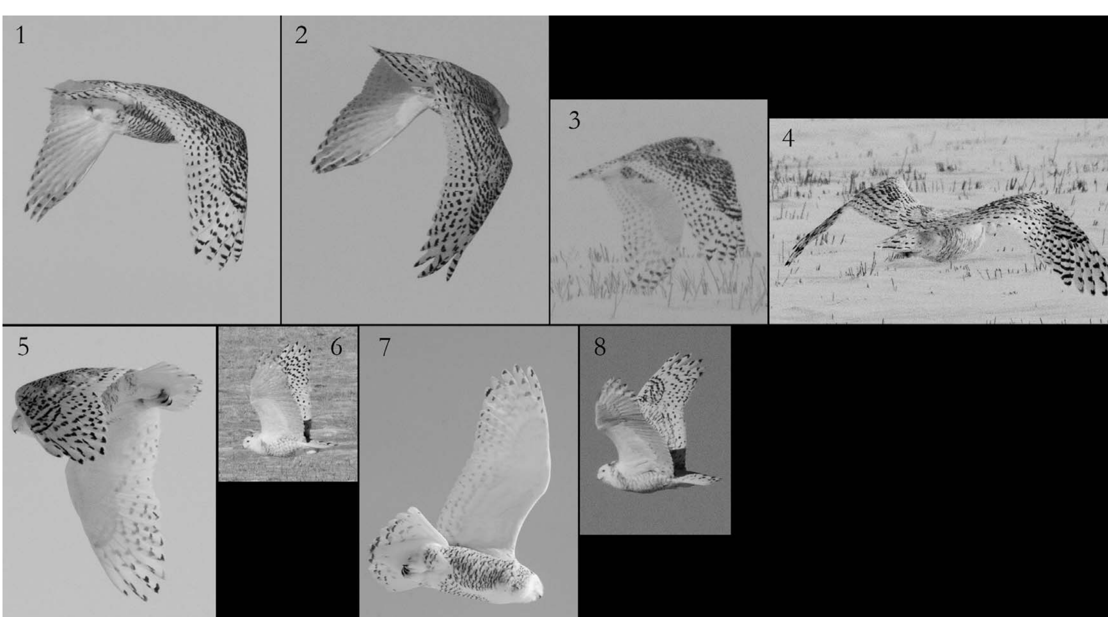

Figure 6. Female Snowy Owls photographed in southern Saskatchewan on 5 February (numbers 1 and 2), 15 February (numbers 3 and 4), 17 February (numbers 5 and 6) and 18 February (numbers 7 and 8), 2014.

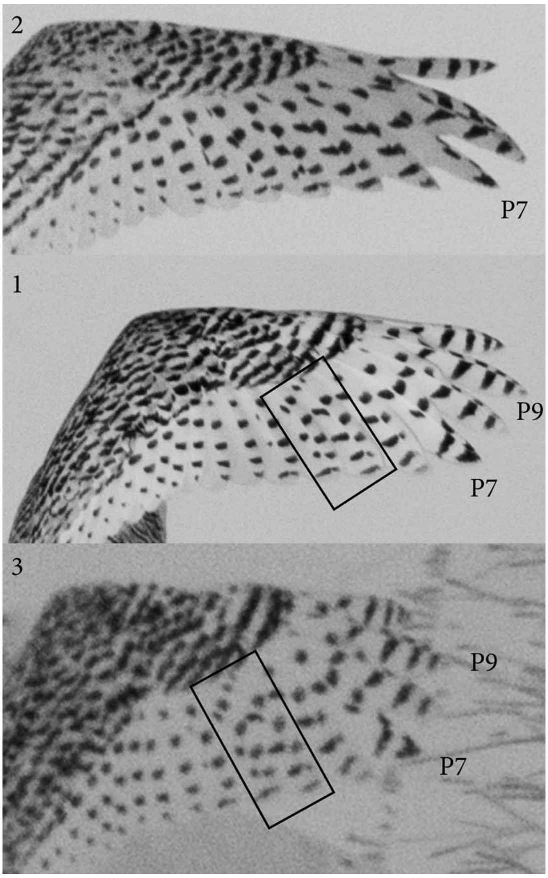

Figure 7. The right wings of the three first females shown in Figure 6. Because all images show birds with juvenile P8 – P10 (Solheim 2012), and adult P7, they are obvious candidates for comparison. For bird number 1 and number 2, it is sufficient to note the differences of the bar patterns on primary P7 to see that these are different individuals. On female 1, the second bar on P7 crosses over the entire width of the inner vane, whereas on female 2, this bar is a thin line toward the rachis. Although image 3 was taken under difficult light conditions at long distance and is blurred when magnified, it is possible to compare the shape of the bars with those on the other images. The pattern of the bars on P7 is similar to the pattern on P7 on image 1. Similarly, the bars on P9, which meet in a zig-zag pattern toward the rachis (as opposed to the bars on P10), are similar in both images 1 and 3. The arrangement of the bars on P4 and P5 within the squares is very irregular and distinctive, and similar on the two images.

Museum in Trondheim. The dead owl too had molted P5 on its left wing. When I compared the primary P3 on the photos of the flying owls and the dead owl, I found they differed markedly in how the three outermost dark bars met toward the rachis (Fig. 5). The dead owl was definitively not the one that was encountered earlier by the two photographers.

Female Snowy Owls on Wintering Grounds. During February 2014, I photographed eight flying female Snowy Owls in southern Saskatchewan on their wintering grounds (Fig. 6). Enlargement of the images of the wings of the birds demonstrated that images 1 and 3 portrayed the same individual, whereas the other birds were different individuals, based on differences of the primary P7 alone (Fig. 7).

Subadult Breeding Great Gray Owl Males at Neighboring Nest Sites. In 2014, I found two nests of Great Gray Owls in southeastern Norway that were spaced 810 m apart. At both nests, the male was a first-year bird, as determined by capture at one site and good wing photos of the flying male at the other site (Fig. 8). Because only five of 64 breeding Great Gray Owls that I aged were first-year birds in 2014 (R. Solheim unpubl. data), there was a possibility that these two neighboring nests were attended by a bigamist male. I compared the wing photos of the captured bird and the flying bird (Fig. 9). The dark bars on the inner vane of P2–P4 were wider than the light areas between them on one bird, but similar in width on the other bird. On P4 there was a dark area along the rachis combining bars 3 and 4 on inner vane on one bird, visibly different from the same area on P4 on the other individual. Thus, I determined that they were different individuals.

Female Great Gray Owls at the Same Nest at a 2-yr Interval. On 28 May 2011, I caught, banded, and photographed a female Great Gray Owl nesting in an old Northern Goshawk (*Accipiter gentilis*) stick nest. This bird was a first-year breeder, as all its wing feathers were juvenile. Two years later, the nest was once again occupied by Great Gray Owls. Although I was unable to catch this female, good wing images (Fig. 10) revealed that she had molted twice (Solheim 2011) and was thus hatched in 2010. She was thus the same age as the female that bred at the same location in 2011. Because the wing of the 2013 bird had retained several juvenile feathers, I compared these with the same feathers on the female from 2011. The outermost crossbar on P1 and P2 produced the best images, and clearly differed between individuals (Fig. 11), demonstrating that the female in 2013 was not the same bird as in 2011.

Figure 8. Breeding juvenile male Great Gray Owls encountered at two nest sites 810 m apart on 6 June 2014. The square marks the section of the primaries that presents the best area to compare bar patterns of primaries with those on the outstretched wing of the captured male.

DISCUSSION

Photos of the outstretched wings of Great Gray and Snowy owls can be used to identify individuals based on ages of molted feathers and barring or spot patterns on the feathers. For Snowy Owls, particularly females, the dark spots and bars of adult primaries usually show more variation across individuals than do the juvenile feathers (R. Solheim unpubl. data). However, old Snowy Owl males have few dark spots on their primaries, and some may lack spots altogether. This method is rarely, if ever, useful for such individuals. However, even when the patterns of color on the feathers are not distinctive, wing photos can still be used to identify raptors based on the presence of gaps in the wing or partly grown feathers during a molt sequence. Some individual raptors may have such specific barring patterns that even one molted flight feather can identify a specific bird (Selås et al. 1990).

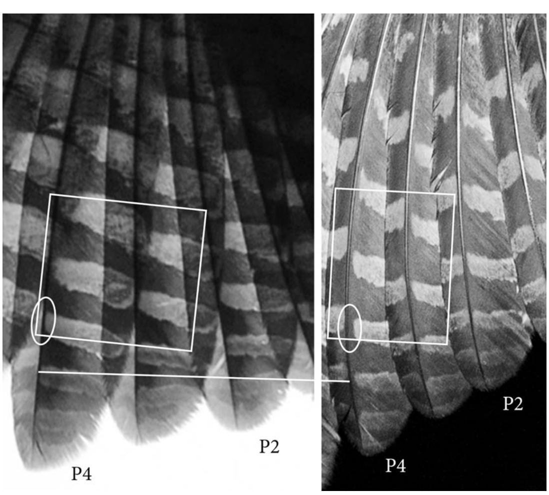

Figure 9. Primaries P2–P4 of the flying (left) and captured (right) male Great Gray Owls from Figure 8. The section from the flying bird has been mirrored. Note that the second bars from the tip of primary P4 are aligned on captured bird, as opposed to skewed toward the rachis on the flying bird (white line), that the third bar on the inner vane of the captured bird stretches in a thin line along the rachis toward the fourth bar (white circles), and that the dark bars within the white squares are conspicuously thicker than the light section between them on the captured bird, but nearly similar in thickness on the flying bird.

Although birds in hand present the best opportunities for taking good wing images, it is often impossible to catch all individuals in a small group or population. In this case, taking in-flight photos of the individuals that cannot be caught can be very useful to build a database that can be used to individually recognize all or most individuals. Even a photo taken at long range or slightly out of focus can be valuable if it shows most of the flight feathers from the upper side of the wing. A database built of wing photos can be used very efficiently within one molt cycle (late autumn to early next summer) by checking all individuals against each other. In Snowy and Great Gray owls, each flight feather is typically retained for 2–3 yr before being molted (R. Solheim unpubl. data). Some feathers may even be kept for

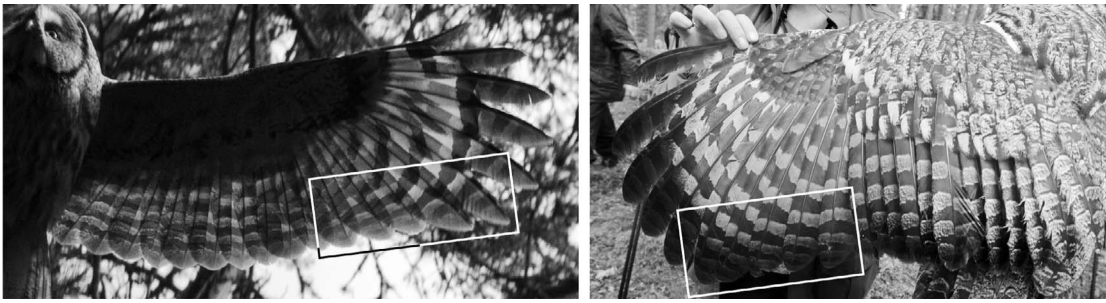

Figure 10. Underside of the left wing of the female Great Gray Owl photographed flying at a nest site on 16 June 2013 (left image), where the breeding female in 2011 was captured on 28 May (right image).

up to 4 yr. This implies that it may be possible to compare a bird with others photographed within a time period of up to 3 yr, and even maybe 4 yr.

Both Great Gray Owls and Snowy Owls occasionally have irruptive movements, during which time members of the public report frequent sightings of owls. However, such reports may overestimate owl numbers if several people see the same bird. In such cases, taking photographs of the free-ranging birds could give a more accurate estimation of the number of individuals at a specific locality. Such digital photos may also indicate the age classes involved in an invasion (Solheim 2014a).

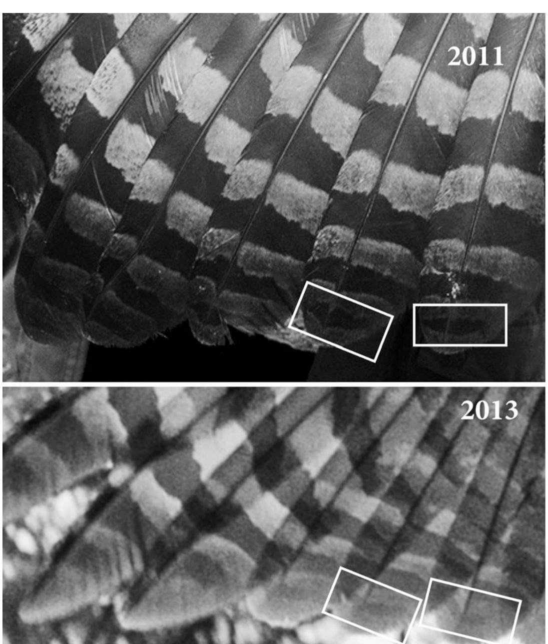

Figure 11. Primaries P1–P5 of the images in Figure 10. The section from the flying female has been mirrored (lower image). The squares outline the outermost bars on primaries P1 (right) and P2, which are still juvenile on the bird from 2013. Note that the bars on P1 are angled toward the rachis on the 2013 female, but straight on the 2011 female. On P2 the bars get markedly broader toward the rachis on the 2011 bird, whereas they are evenly broad on the 2013 bird.

By systematically photographing both wings of all individuals caught for banding, it is possible to build an archive to which other individuals may be compared. In principle, this method could be used as a capture-recapture method to estimate the size of a subpopulation, as has been done successfully for humpback whales (*Megaptera novaeangliae*; Smith et al. 1999). Images of faces of Australian sea lions (*Neophoca cinerea*) have been used with whisker spots as clues to test whether individuals can be identified by computer programs (Osterrider et al. 2015). However, the images had to be strictly standardized with regard to distance and angle of the face to work. Such software would probably only work on wing images of owls from captured birds. Wing photos of free-ranging birds come in a wide variety of angles and light conditions, and would have to be checked manually by a human observer.

I have not yet used wing images to estimate the size of any subpopulation of Great Gray or Snowy owls. However, I have captured a considerable number of adult birds of both species on breeding and wintering grounds (Solheim et al. 2007, Solheim 2014b, Jacobsen et al. 2012, Solheim et al. 2014). It takes dedication and a large effort in terms of time and resources to capture such birds, and there are always individuals that cannot be caught. Taking photos of such individuals in flight is both easier and less expensive than getting the birds in hand, and in this respect I am convinced that wing images may be applicable as a tool to census populations of Great Gray and Snowy owls.

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