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AWARE

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**The Secret Lives of the Ruff:
One Gene & Three Males
By Peter Hudson
and Kaitlyn Baker**

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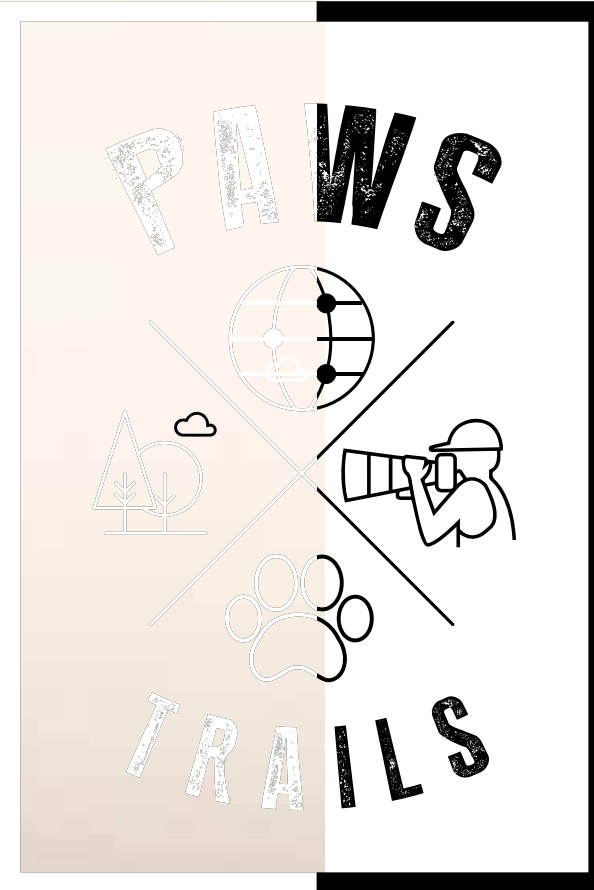
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THE STORY

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the Ruff: One Gene &
Three Males
By Peter Hudson and
Kaitlyn Baker

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Photo By:
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Raghul Patteri
Editor

Welcome to PT Aware. In this edition, *The Secret Lives of the Ruff: One Gene & Three Males*, Dr. Peter Hudson and Kaitlyn Baker take readers deep into one of nature's most fascinating evolutionary stories. This piece brilliantly unpacks how a single genetic inversion gave rise to three distinct male strategies in ruff sandpipers: territorial independents, cooperative satellites, and stealthy faeders, each locked into its role for life. Beyond the captivating biology, the article underscores urgent conservation challenges as ruff populations collapse across Europe, reminding us that preserving biodiversity means safeguarding not only species but the genetic architectures that sustain their unique behaviors. The narrative blends cutting-edge science with vivid field observations, offering a compelling call to protect both wetlands and the evolutionary marvels they harbor.

Dr. Peter enriches this edition with his exceptional Ruff photography, offering a visual complement to the insightful narrative. Looking ahead, our next feature will celebrate the vibrant world of kingfishers, so start curating your finest kingfisher shots and get ready to share their brilliance!

EDITOR'S DEN



Photo by: © Peter Hudson

FOUNDERS' NOTE

Welcome to the 37th edition of PT Aware, a bi-monthly magazine dedicated to deepening awareness one species at a time.

This platform was created to spotlight the lives of wild species, amplify conservation voices, and inspire conscious action. Each edition focuses on one species, delving into its natural history, the threats it faces, and how we can play a role in protecting it. As always, PT Aware remains completely free and open to all who care for the wild.

In this issue, we explore the story of the Ruff (*Calidris pugnax*), a fascinating wader known for its extravagant breeding plumage and complex courtship behavior. Though beautiful, this species now navigates the challenges of shrinking wetlands, disrupted migrations, and climate shifts. We hope this feature brings you closer to the Ruff and its quiet fight for survival.

We also take a moment to honour Dr. Jane Goodall, who passed away last week. Her life's work transformed global attitudes toward animals, conservation, and hope. Her words and wisdom continue to guide and inspire us.

May we carry her legacy forward with compassion, curiosity, and action.

Explore more editions at www.pawstrailsmagazine.com

Sincerely,

**Hermis Haridas &
Nisha Purushothaman**

Founders - Paws Trails





Peter Hudson is a scientist, photographer, and conservationist. He undertook his first scientific expedition to Africa at the age of 21 and has been a regular visitor ever since. Passionate about nature, he manages his own 36-hectare nature reserve in Pennsylvania which is home to bears, bobcats, and other animals.

In his professional career, Peter is the Willaman Professor of Biology at Penn State University. The focus of his research has been the infectious diseases of wildlife and in particular how new diseases emerge. For the past 11 years, he has been working on how and why viruses move from bats to humans in an attempt to predict when viral spillover occurs. He has also been studying the wolves in Yellowstone, tortoises in the Mojave Desert, and bighorn sheep in Idaho.

Peter is the Conservation Director at Paws Trails and uses his skills as a scientist and educator to increase awareness about conservation issues. He is supported by two interns at Paws Trails: Hayden Kissel and Shreya Menon. He is also heavily involved with the Random Good Foundation that undertakes storytelling for social change. He is an adjunct Professor at The Nelson Mandela African Institute of Science and Technology based in Arusha, Tanzania, and a Fellow of the Royal Society.



THE STORY

The Secret Lives of the Ruff: One Gene & Three Males

By Peter Hudson (Conservation Director, Paws Trails)
& Kaitlyn Baker

Images by: Peter Hudson



Recent genetic discoveries reveal how one of nature's most spectacular mating systems evolved and why it matters for conservation

One of my most enjoyable experiences this past year was sitting in a hide on the edge of a Finnish wetland, witnessing one of nature's most extraordinary spectacles. Male ruff sandpipers (*Calidris pugnax*) were gathering on traditional display grounds called leks and I watched as they performed an elaborate mating ritual that resembles something between a medieval tournament and an avant-garde ballet. Remarkably, no two males looked the same and not all the males were playing by the same rules.

Three Males, Three Strategies

The displaying birds fall into three distinct types. Large, dark-plumed males with ornamental neck ruffs (from which the species takes its name) aggressively defend small territories. These “independent” males are the knights of the lek, battling for prime display spots to display to the visiting females that will then choose who to mate with. Scattered among them are equally striking males with pale, creamy plumage who seem oddly passive, co-displaying peacefully alongside the aggressive independents. These “satellite” males don't defend territories but partner with dominant males, helping with defense while sneaking matings when their hosts are momentarily distracted.

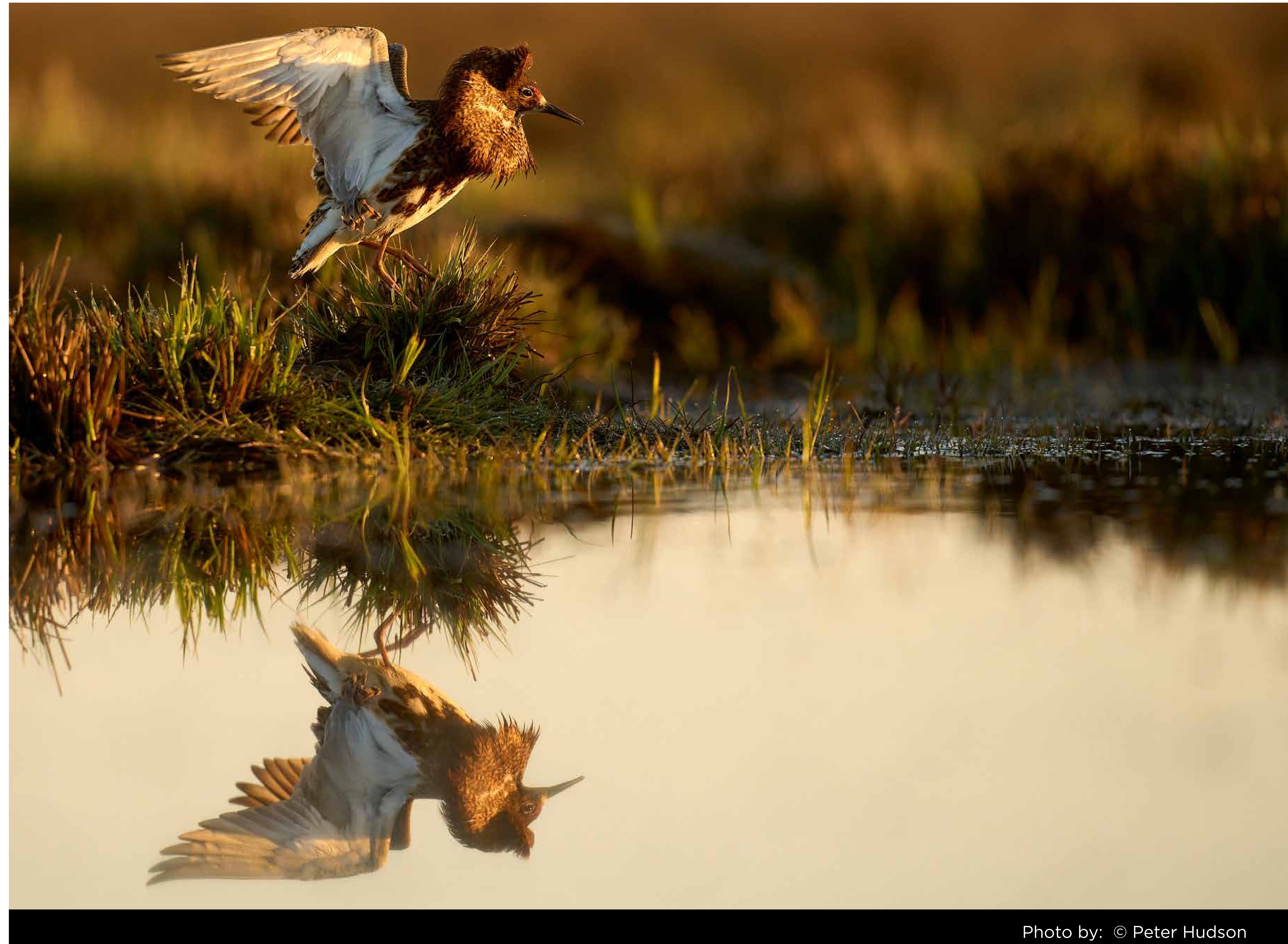


Photo by: © Peter Hudson

If you're extremely lucky, you might spot the rarest player in this drama: a small, drab male that look remarkably like a female. Known as "faeders" (from an old Frisian word meaning "father"), they've taken deception to an extreme, mimicking female appearance and behavior to slip past aggressive territorial males and steal copulations while others are preoccupied with displaying and fighting.

What makes this system truly extraordinary is that these strategies aren't flexible. Males can't switch between types, and each male is locked into his role for life, determined by his genes. Recent groundbreaking research has now revealed exactly how nature creates these three radically different males: through evolutionary changes to a single gene (Loveland et al. 2025; [DOI: 10.1126/science.adp5936](https://doi.org/10.1126/science.adp5936)).

The Supergene Solution

Some 3.8 million years ago, a large DNA segment containing more than 100 genes flipped backwards in an ancestral ruff—like a paragraph in a book being written in reverse. The genes remain functional but are now arranged in reverse order. This "supergene" is inherited as a single package, rarely recombining with the normal chromosome. Dark-ruffed territorial "independent" birds carry two copies of the ancestral, non-inverted chromosome, while white-ruffed "satellites" and female-mimicking "faeders" each carry

one ancestral chromosome and one inverted copy.

Interestingly, even though faeders were discovered only recently, they evolved first. Satellites emerged just 70,000 years ago through a rare recombination event, making them the newest players in this ancient game.

The Testosterone Paradox

Given their striking differences in appearance and behavior, it's unsurprising that the three male types differ profoundly in their hormone profiles. Independent males have high circulating testosterone and low androstenedione (A4) exactly what you'd expect in aggressive, territorial males constantly displaying and fighting. A4 does not change the behaviour but acts as a storage form that can be converted into testosterone when needed, and back again when not.

In contrast, satellites and faeders show the opposite pattern: testosterone concentrations are 10 times lower and A4, 10 times higher. They essentially keep their testosterone in storage rather than expressing it, so preventing the aggressive behavior. Since testosterone drives aggression and territorial behavior in vertebrates, low-testosterone satellites and faeders simply can't compete in the rough-and-tumble world of lek dominance. Instead, evolution has favored alternative tactics.

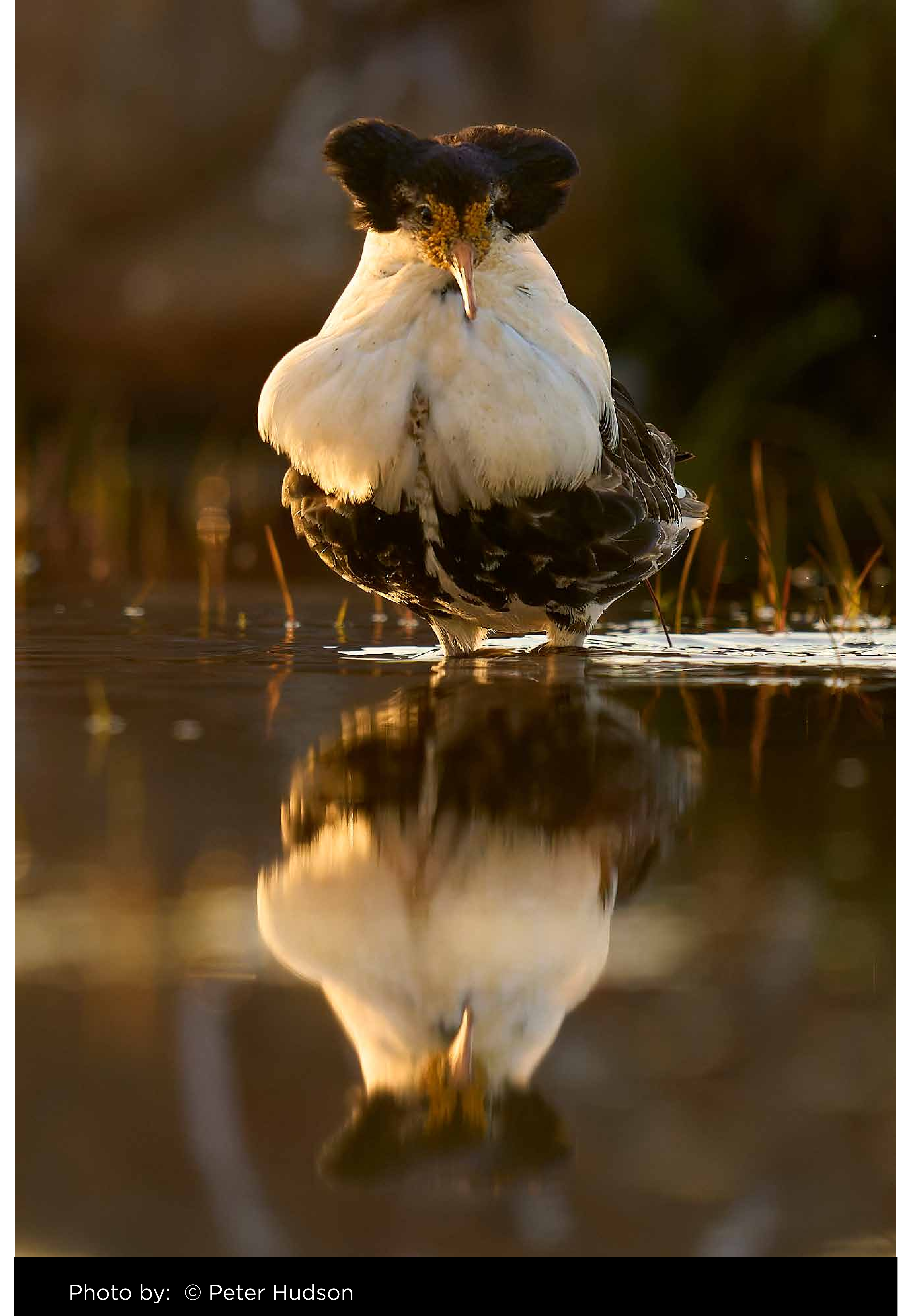


Photo by: © Peter Hudson



Photo by: © Peter Hudson

But how does carrying a genetic inversion result in different hormone profiles? To find out, researchers conducted extensive sampling in multiple tissues from all three male types captured during the breeding season. The team at the Max Planck Institute for Biological Intelligence in Germany discovered that a gene called HSD17B2 is highly active in faeders and satellites, working three times harder than in independents to convert testosterone into A4. Moreover, in what appears unique to these morphs, the gene is highly active in blood cells, preventing the hormone from reaching tissues that would trigger aggressive behavior. The inverted gene essentially deactivates the potent hormone before it can influence behavior.

Conservation Implications

This discovery has profound implications beyond scientific interest. Ruff are declining across much of their range classified as Near Threatened globally by the IUCN and face severe pressures throughout their distribution. The extinction of breeding ruff from Germany and the dramatic population collapse in the Netherlands represents one of the most severe declines of any European breeding bird. The causes are more complex than simple habitat loss, involving agricultural intensification, hydrological changes, predation pressure and climate disruption that have fundamentally altered the wet grassland

ecosystems ruffs depend on.

Ruffs were once widespread across the wet meadows and marshlands of lowland northwestern Europe. By the late 20th century, breeding had essentially ceased in Germany, and Dutch populations had crashed from thousands of breeding males to just a few dozen. The UK lost its breeding population even earlier, in the 19th century. This wasn't a gradual range contraction; it was a total collapse.

The transformation of wet grassland agriculture has been the single most important factor. Systematic wetland drainage has been catastrophic. Ruffs don't just need grassland they need wet grassland with specific moisture conditions. Ruff chicks require abundant surface-active insects during their first 2-3 weeks of life. This insect abundance is temperature-dependent, with peak emergence historically timed to spring conditions. However, climate disruption has caused earlier springs and earlier insect emergence, while ruff migration timing remains triggered by day length. Consequently, ruffs now arrive after insect numbers have peaked, leaving chicks without adequate food a mismatch particularly severe in Germany and the Netherlands.

Ruff migration routes span continents, making them vulnerable to habitat loss at multiple points. Conservation requires protecting not just breeding sites, but the

entire network of wetlands used during migration and wintering.

Understanding the genetic basis of their extraordinary mating system is crucial for ruff conservation. The proportion of satellite and faeder males are maintained by balancing selection as one type becomes rarer so it is favored by selection. Loss of this genetic diversity could destabilize entire populations. If populations become too small and fragmented, rare morphs could be lost entirely, collapsing the lek mating system that has evolved over millions of years.

Photographing Ruff

I admit that photographing ruff was wonderful and I traveled with the excellent company Finnature and had the great fortune of spending time with the generous and helpful owner of the company, Jari Peltomäki. They're a wonderful group to work with and had hides constructed that we entered before dawn and watched the birds on an area that was not a traditional lek. Dawn lek displays offer spectacular action, with multiple males in elaborate plumage performing in close proximity. Their traditional leks are highly protected and require proper access arrangements. They should never be approached during displays, as disturbance can disrupt mating and impact breeding success.

A Window Into Evolution

The ruff mating system represents

one of evolution's most elegant solutions to reproductive competition. Rather than all males competing directly using the same rules and tactics, the supergene has enabled three distinct strategies, each successful in their own way. The discovery that changes to a single gene can orchestrate such profound differences in physiology, morphology, and behavior powerfully demonstrates how evolution works. Small genetic changes can create wholesale shifts in life history strategy.

As ruff populations continue to decline, understanding the genetic architecture of their extraordinary diversity becomes increasingly urgent. These charismatic shorebirds remind us that conserving biodiversity means more than simply protecting species it means preserving the genetic diversity and the evolutionary innovations that make each species unique. In the case of the ruff, that means protecting not just the birds themselves, but the intact wetland ecosystems and genetic diversity that allow three very different males to continue their ancient dance.

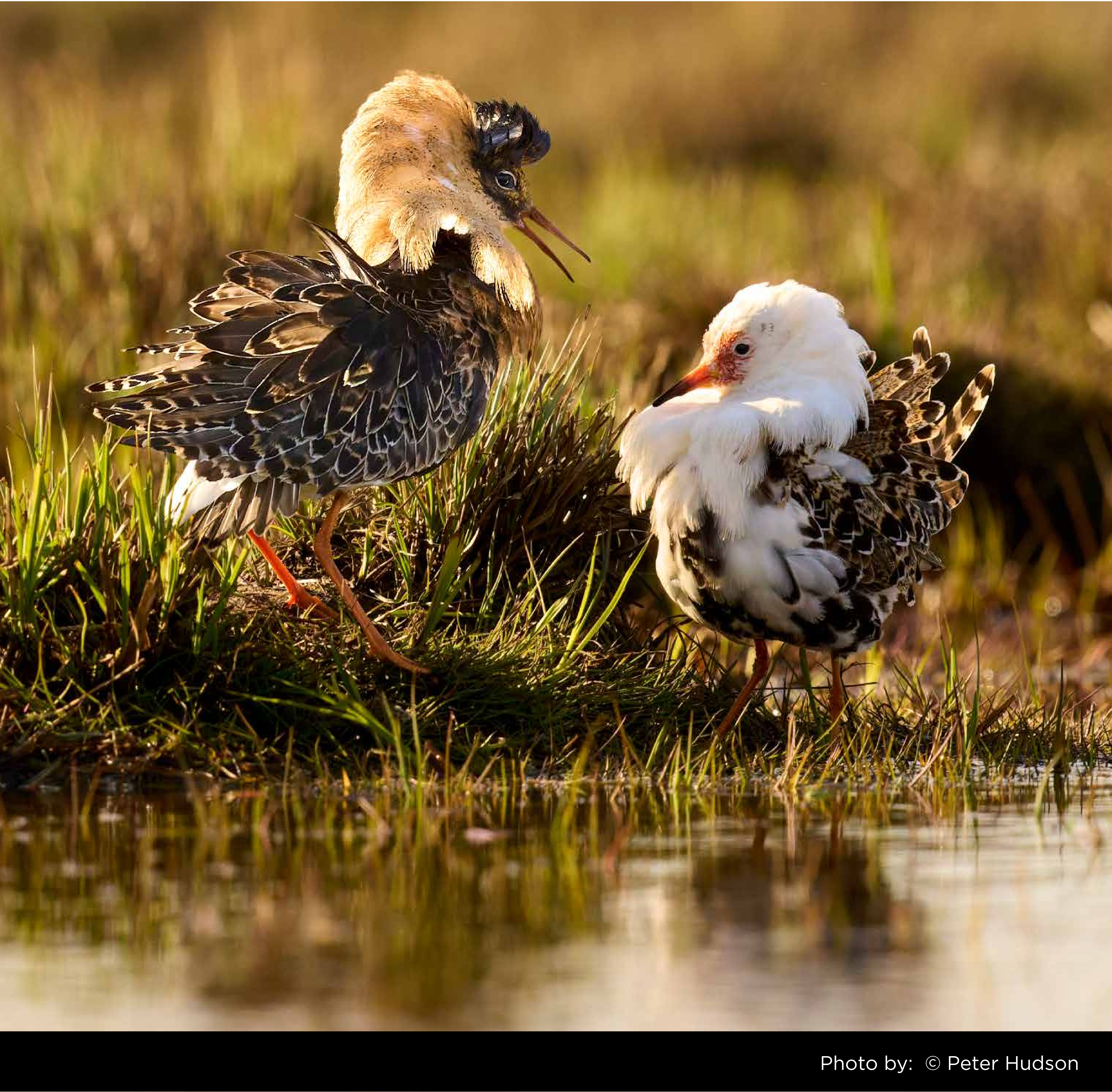


Photo by: © Peter Hudson

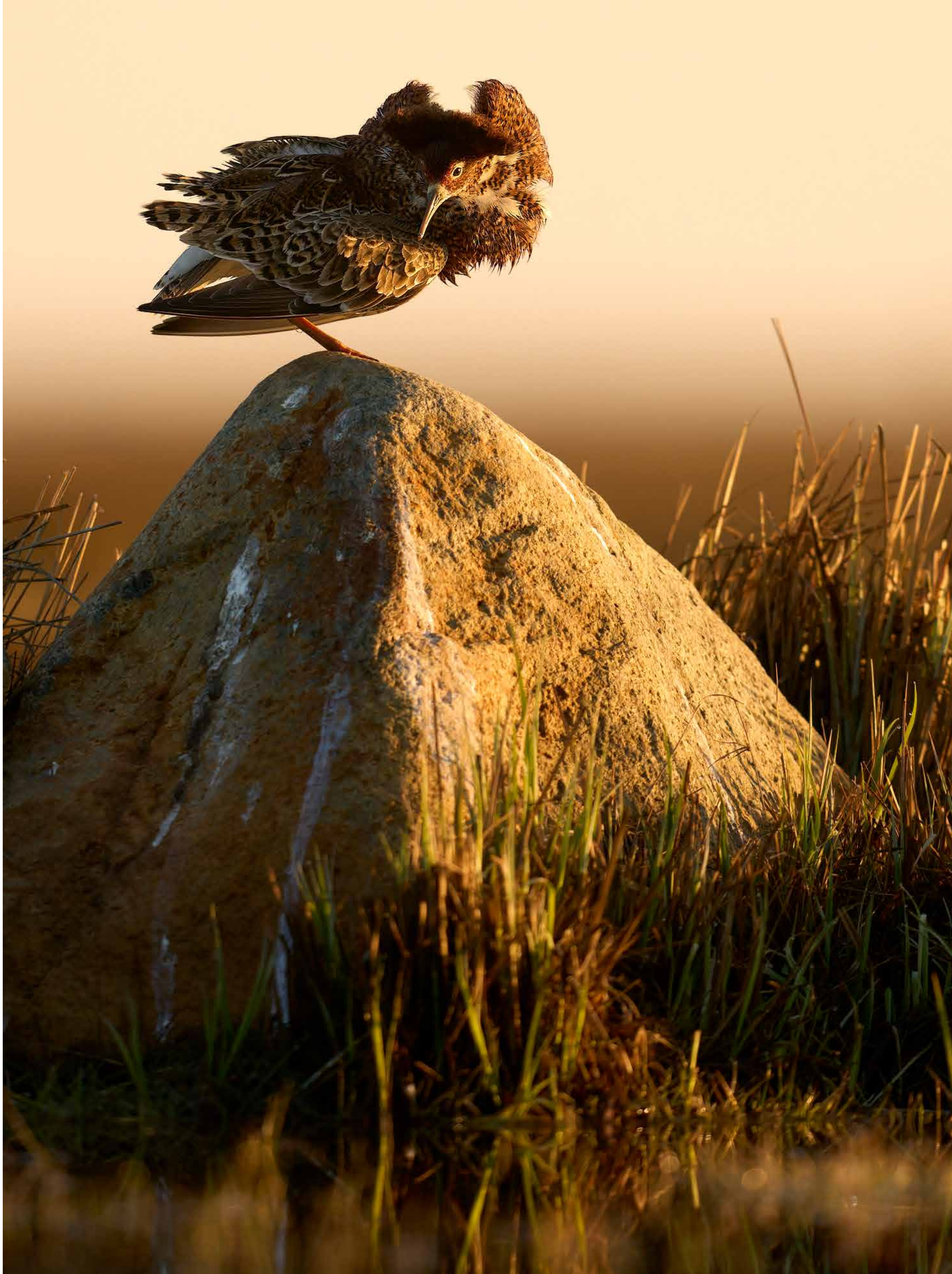


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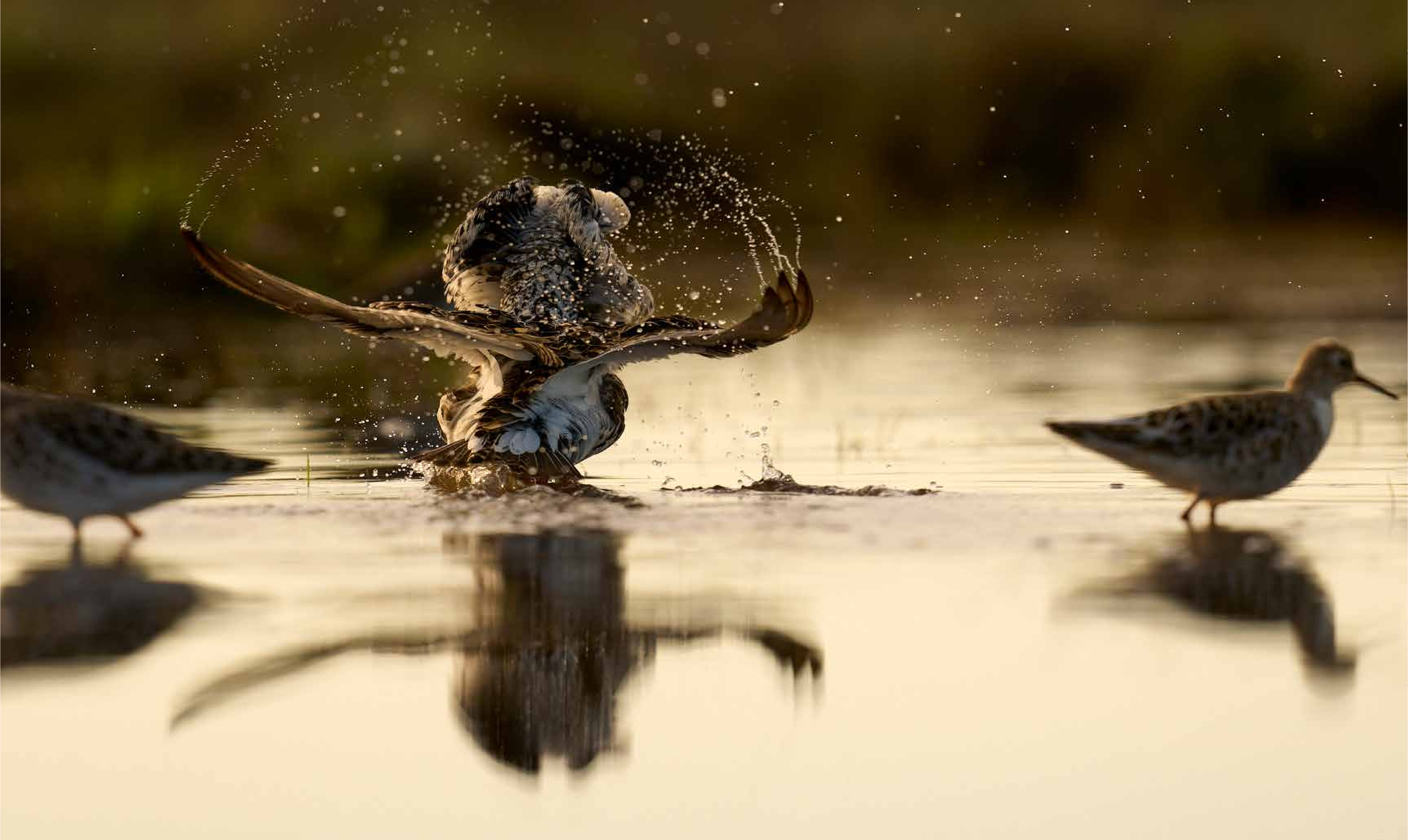












































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