SALIVA

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Several statements circulating in the eagle-cam watching world assert that **saliva and nasal fluids** passed from a breeding parent to a new hatchling provide important benefits, including **digestive enzymes**, **antibodies**, and **moisture to enable the chick to swallow** food.

I know of only a handful of comments in publications about raptors that refer to saliva passing from parent to chick, none of them supported by citations of scientific evidence. For instance, in his book *Birds of Prey* (1995, targeted mainly to falconers), Fox remarks that "females feeding young chicks drool large quantities of liquid onto the food for the chick to ingest and **it is not clear** if this fluid is salivary or nasal, or both, in origin" – or, I would add, from the food itself (emphasis added). Wiemeyer 1981 comments in a report on breeding by captive Bald Eagles that "when the eaglets were less than 1 week old a saliva-like fluid was seen dripping from the tip of the upper mandible of the adult feeding the young, thereby providing extra moisture and **possibly** digestive enzymes to the young with the pieces of food" (emphasis added).

To learn whether any of the claims are valid, I took a deep dive into peer-reviewed research on the biology of avian saliva, nasal secretions, and digestive and immune systems, as well as embryological development of a chick.

What is the make-up of saliva and nasal fluids?

As in all vertebrates, saliva in birds is made up primarily of **mucus**, a mixture of water and the protein **mucin**. Mucus **keeps the oral cavity lubricated** and **moistens food to make it easier to swallow**. Both mucus and the membrane whose cells produce it serve as barriers to toxins and pathogens that may enter the mouth. The **nasal cavity** just inside the nostrils (or nares) also is lined by a membrane that secretes mucus, which helps trap incoming debris and can protect against foreign agents. It is normal for excess mucus to drip out of the nares or be expelled in the form of a sneeze.

Do new hatchlings produce their own saliva and nasal fluids?

An eaglet embryo's **salivary glands** begin to form toward the **end of the second week of development**, and they are developed and functioning by the time **the eaglet hatches**. The **mucous membranes in the oral and nasal cavities** are producing mucus by the **middle of the third week** of embryonic development. Embedded in the nasal membrane are **nerve endings** which convey smell signals to the bird's olfactory bulb, and these neurons start working as the membrane begins functioning. This means that the **embryos can learn to distinguish smells before hatch**, even before the internal pip of the air sac. (*Recent research shows that most birds have a stronger sense of smell than previously believed.)*

Do hatchlings have difficulty swallowing?

Anyone watching the **first feeding** of a hatchling eaglet, which can happen within 2 or 3 hours of hatch, knows that it has no problem gulping down small, solid chunks of meat offered by a parent. A hatchling's tongue already has baby-sized **rear-pointed papillae** extending from the back of the tongue, which push the food back toward the esophageal opening.

And clearly the reflexive movement that sends the food down the esophagus is functioning. In this slo-mo video (*click on the image*), note that the parent turns its beak sideways to make it easier for the chick to access the food. This position allows some liquid to drip out of the side of the beak and **into the nest** – not into the chick's mouth.

Studies have shown that bird embryos can swallow **even before hatching**. About **two-thirds of the way through the incubation period** they begin swallowing some of the amniotic fluid in which they are bathed.

Are there digestive enzymes in saliva or nasal secretions?

In some species, yes, but as far as I can learn, none have been detected in Bald Eagles. The only digestive enzymes securely identified in avian saliva are those that target **sugars and complex carbohydrates** and break them down into digestible form. The most common such enzyme, amylase, has been found in the saliva of **a few species that eat seeds, grasses, insects, and fruits**, a diet that is plentiful in sugars and carbs. But the diet of carnivores like Bald Eagles is not, so this kind of enzyme is unnecessary, and scientists have found little to no amylase anywhere in their digestive tracts.

How well are new hatchlings equipped to digest food?

A further dive into studies of embryology casts light on a new hatchling's capacity to digest food and to fight off infection, needing no extra help from a parent's saliva. An eaglet's digestive system is fully functional **by the time it emerges from the** egg, complete with digestive enzymes. This is evident in its expulsion of wastes about 12 hours after its first feeding, when its system has extracted all the usable nutrients from the food. (*click on the image for video*)

But **long before an eaglet hatches**, digestive enzymes are produced in **the** yolk **sac membrane**. These break down the lipids, proteins, and carbohydrates in the yolk to supply the embryo with the energy it needs to grow. The digested nutrients are absorbed into the blood vessels that are spread across the membrane, and the capillaries convey the food into the embryo's intestinal cells. These enzymes increase throughout embryonic development, and the intestine itself grows rapidly as hatch nears.

And, as is well known, **just prior to hatch** a chick absorbs what is left of the yolk sac, so its nutrients feed the chick, and its **digestive enzymes** help it process new food during its first 24-48 hours out of the shell.

Does saliva contain antibodies?

I found no evidence in the scholarly literature of any appreciable amount of **antibodies** in the saliva of birds. The only such assertion pertaining to Bald Eagles that I have seen is in Nielsen 1991, a picture-book about a breeding season of a pair of Bald Eagles, which lists no references. The idea may have origins in the phenomenon of "crop **milk**" that **pigeons and doves** feed to their hatchlings. Crop milk, as the name implies, consists of fatty cells that are shed from the lining of the parent's crop, mixed with a healthy proportion of water. Rich in lipids and proteins and some antibodies, it is regurgitated and fed to the chicks during the first few days after hatch. (And, of course, it is not strictly "milk" as it is not secreted by a mammary gland.) **Eagles do not produce** crop **milk.**

Do new hatchlings have any immunity against infection on their own?

To answer that question, it's useful to survey **how immunity works** in birds. Like all vertebrates, birds are protected by two types of immunity: **innate immunity** and **adaptive immunity**.

Innate immunity is the natural, non-specific, protection that is provided by cells throughout the body. Agents of innate immunity do not target specific pathogens. They include **physical barriers** against penetration by harmful microbes, including skin and scales, feathers, and membranes in the respiratory and digestive tracts. **Membranes** are very effective in thwarting infection by helping prevent absorption of toxins and pathogens. Mucous membranes host **macrophages**, white blood cells that can ingest foreign cells and break them down, especially in the intestine. **Mucus** can trap infectious organisms and transport them from the body in a sneeze, phlegm, excretion, or sputum (which can be swallowed and expelled via the digestive system). **Beneficial microorganisms** in the skin, mucous membranes, and especially the digestive tract can neutralize bacteria & viruses. Defensive **peptides** can disable infectious agents.

By the time an eaglet hatches, its **innate** protections are well developed. **Mucous membranes** begin to develop during the **second and third weeks of embryological development**, and intestinal cells are producing **mucin** by the **end of the embryonic period**. Early forms of **macrophages** develop in the yolk sac and are functional in the digestive system by the time a chick hatches. Infection-fighting **peptides** appear as early as the **second week** of embryonic development. The developing embryo receives **beneficial microorganisms** from its mother during egg formation, and during brooding more such microbiota easily transfer to the hatchling from both parents.

Adaptive immunity is provided by **antibodies**, proteins that target specific pathogens and adapt to retain a memory of them for future defensive action. Antibodies are produced by white blood cells, or lymphocytes, named **B cells** for the organ in birds where they mature, the **Bursa of Fabricius** (after the 17th-century scientist who discovered it). This organ is now commonly referred to as the **cloacal bursa**, as it is a small sac growing out of the wall of the cloaca. B cells and antibodies "learn" the pathogen so they can recognize it if it invades again – what we call "immunity."

Mature B cells from the bursa populate lymphatic tissues throughout the body, including mucous membranes, the spleen, areas of the intestine, the bronchi in the respiratory tract, skin, and the nasal cavity. When a B cell encounters a pathogen, it is activated to multiply and to produce increasing numbers of antibodies that can bind to that pathogen and destroy or disable it. The action of B cells is reinforced by lymphocytes called **T cells**, which mature in the Thymus gland and also populate lymphatic tissues throughout the body.

But long **before hatch**, a bird embryo has a good supply of **antibodies provided by its mother**. She deposits **antibodies into the** yolk while it is forming in her ovary, along with fats and proteins and other nutrients. And when the egg moves down the oviduct, more maternal **antibodies are transferred into the** albumen. Antibodies in the yolk enter the embryo's blood stream beginning a little over **halfway through incubation**. At about the same time, the embryo swallows albumen and its antibodies.

The embryo's own **adaptive** immune system takes a little longer than innate protections to mature. The **cloacal bursa** begins to grow in an embryo**'s second week**, and lymphocyte stem cells appear there in the **last third of the incubation period**, where they begin to proliferate and to develop antibody-producing capability. Lymphocytes enter the embryo's blood stream in the **third week of incubation** and begin to migrate to other lymphatic tissues about **a week before hatch**, slowly at first, then increasing till hatch. By that time, most of the lymphocytes in the bursa are mature and ready to produce antibodies.

Stem cells of the thymus start to develop in the embryo by about **the second week**, and the organ is well developed by **the fourth week**. Lymphocyte stem cells from the spleen and liver travel to the thymus in waves between about the **middle of the second week to the fifth week**, where they mature into antibody-capable T cells. In the **last week of incubation** they begin to migrate out to peripheral lymphatic tissues where they can begin to detect foreign cells.

The transfer of maternal antibodies from the yolk into the embryo increases significantly during the **last 3-5 days of incubation** and are at a high level in the chick at hatch, but then they begin to decrease. The maternal antibodies are specific for pathogens encountered by the mother during yolk deposition and egg formation in her oviduct, but a chick will encounter new pathogens in its wider environment. So its own antibody-producing capability ratchets up at an increasing pace after hatch. The bursa increases in size quickly and produces an increasingly diverse repertoire of B cells and antibodies, especially in response to infectious agents in the environment, and their dispersion to other lymphatic tissues speeds up. The **Harderian gland**, a small organ behind the eye in the optical orbit, is **functional by the time the chick hatches.** It secretes fluid that lubricates the cornea of the eyes & the nictitating membrane, and the secretion contains lymphocytes and antibodies that **help protect the hatchling's precious eyes** from infection.

The **cloacal bursa** remains active while the eaglet continues to grow, but it **regresses by the time the bird is sexually mature**, in response to increasing gonadal hormones. The thymus gland follows the body's annual cycle, reaching a peak during molt and shrinking in fall and winter until the next breeding cycle has begun. Like the cloacal bursa, the thymus **begins to atrophy later in the bird's life**. Lymphocytes that have moved to other lymphatic tissues continue to divide and produce antibodies in response to pathogens throughout a bird's life.

To sum up

- There is no scientific evidence to support assertions that a Bald Eagle's saliva or nasal fluids contain digestive enzymes or antibodies to transfer to hatchlings during feeding.
- By the time it hatches, an eaglet has been producing saliva and nasal fluids on its own.
- By the time it hatches, an eaglet has already been swallowing fluids inside the egg.
- During embryonic development the yolk sac membrane produces digestive enzymes to process the nutrients in the yolk and pass them into the blood stream of the developing embryo.
- By the time it hatches, a chick's digestive system, including digestive enzymes, is fully functional.
- A breeding female deposits some of her antibodies into the yolk as it develops in her ovary, which are transferred into the embryo's blood stream, and they continue to protect the eaglet from infection after it hatches.
- As the egg is forming in the oviduct, the female deposits some of her antibodies into the albumen, which is swallowed by the embryo, and these continue to protect the eaglet from infection after it hatches.
- By the time it hatches, a chick's innate immune system (barriers, mucous membranes, macrophages, peptides, beneficial microorganisms) is in place and can protect against many potential infections.
- After hatching the chick's adaptive immune system develops quickly and produces antibodies to protect against new pathogens encountered in the environment.

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Research on avian digestion, the immune system, and embryology has focused largely on domestic chickens and other precocial species like geese and waterfowl, although some involve altricial or semi-altricial birds, including a few songbirds, pigeons, quail, and raptors, including Red-tail Hawks, Eurasian Kestrels, American Kestrels, Great Horned Owls, Barn Owls, and Andean Condors. While there are significant differences between precocial and altricial species, scientists have demonstrated that the stages of embryo development are the same across all bird species, and that the rate of development is relatively constant, no matter the developmental mode or the length of the embryo period. Most timings of the embryonic stages of development in these studies are specific to domestic chickens, whose incubation period is about 21 days. I have used a rudimentary scaling based on the percentage of time elapsed in the embryonic period of chickens to calculate the approximate timing of embryological developments for Bald Eagles, whose incubation period is about 36 days.

B CELLS

The designation "B cells" originated with avian research, and only later did biologists discover that analogous lymphocytes in mammals were produced in bone marrow, so they adopted the term "B cells" from ornithology.

NIELSEN 1991

Nielsen's (1991) assertion that antibody transfer by Bald Eagles occurs via parental saliva contradicts established science. He goes even further by comparing the parents' saliva to milk that mammals feed to their babies: "Saliva is the means for passive antibody transfer from adult to newborn, much the same as mammalian mother's milk is the vehicle for transfer of ***colostrum****, which bolsters the immune system of the newborns." Colostrum is a thick, lipid- and protein-rich milk* ***produced by the mammary glands*** *during the first few days of an infant's life. There is no comparable substance in birds, certainly not in saliva.*

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