

THE USE OF SHEEP WOOL IN NEST CONSTRUCTION BY HAWAIIAN BIRDS

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ABSTRACT.—The use of sheep wool as a nesting material was examined from 1969 through 1975 on the island of Hawaii. Of the 10 bird species studied, six used wool in their nests. Both introduced and endemic birds use wool, with a significantly greater usage by endemic birds.

Use of wool in nests appears correlated with the intricacy of a species' nest, with significant differences between degree of usage in complex and simple nests. Roughly built nests, like those of the Cardinal (*Cardinalis cardinalis*), contained no wool whereas the complex nests of the Elepaio (*Chasiempis sandwichensis*) had a great deal of it. Birds apparently use wool because of its ready availability and its binding quality. They gathered it from tufts that snag on branches as the sheep pass or from dried skins. The amount of wool in each nest varied both interspecifically and intraspecifically, but in all nests only the body contained wool; the lining was always of other material.

A separate study compared an area void of sheep and an adjacent one containing sheep to determine if wool is a preferred and sought-after material. Only the Elepaio was found consistently to travel distances to procure it; the other species used it only when available within their territories.—*Department of Zoology, University of Hawaii, Honolulu, Hawaii 96822.* Accepted 9 December 1975.

SHEEP were first introduced into the Hawaiian Islands by Captain James Colnett in April 1791, when he left a ewe and ram on Kauai (Wyllie 1850). Captain Vancouver (1798) landed a ram, two ewes, and a ewe lamb at Kawaihae, Hawaii, on 14 February 1793 and then proceeded to Kealahou Bay, Hawaii, where he landed another ram and two ewes. The dispersion of sheep over Hawaii is poorly documented, but Judd (1936) stated that Reverend Goodrich saw 8 or 10 dead sheep near the summit of Mauna Kea in 1822. This suggests that feral sheep had become established on Mauna Kea within 29 years of their introduction to the island. Bishop (1852) estimated that 3,000 wild sheep were roaming the island by 1851. Today sheep are distributed over the island of Hawaii in the higher more arid regions, with the herd on Mauna Kea estimated at 1,800 (Fig. 1).

While working in the Hawaii forests I noticed that where feral sheep occur many bird nests contain sheep wool. On the continental United States authors (e.g. Bailey 1928, Bent 1968) cite the use of sheep wool by birds for nesting material, but I can find only one reference to this in Hawaiian literature. Munro (1944) described a nest of the Lanai Amakihi (*Loxops virens*) that was lined with rootlets and some sheep wool.

METHODS

To compare the extent to which wool was used by different species, I collected nests from 1969 through 1975 on the island of Hawaii and recorded the amount of wool in each. The density of sheep in each locality was also noted. The greatest number of nests were collected on the southwestern slope of Mauna Kea, where many of the feral sheep on Hawaii are found.

To ascertain if sheep wool is a sought-after nesting material, a study was initiated in 1970 at Puu Laau, on the southwestern slope of Mauna Kea. Nests were examined from two adjacent areas: one with sheep present and the other with them absent. In 1950 the Hawaii State Division of Fish and Game built an 80-ha holding pen for Mouflon sheep at approximately 2,000 m elevation. In 1967 all sheep were removed from the pen, and it has since acted as an enclosure. No source of wool is available to birds that nest within the enclosure; if they use it in their nests, they must fly outside the fenced plot to collect it. Feral sheep are abundant in the area surrounding the enclosure and wool is available immediately outside the fence.

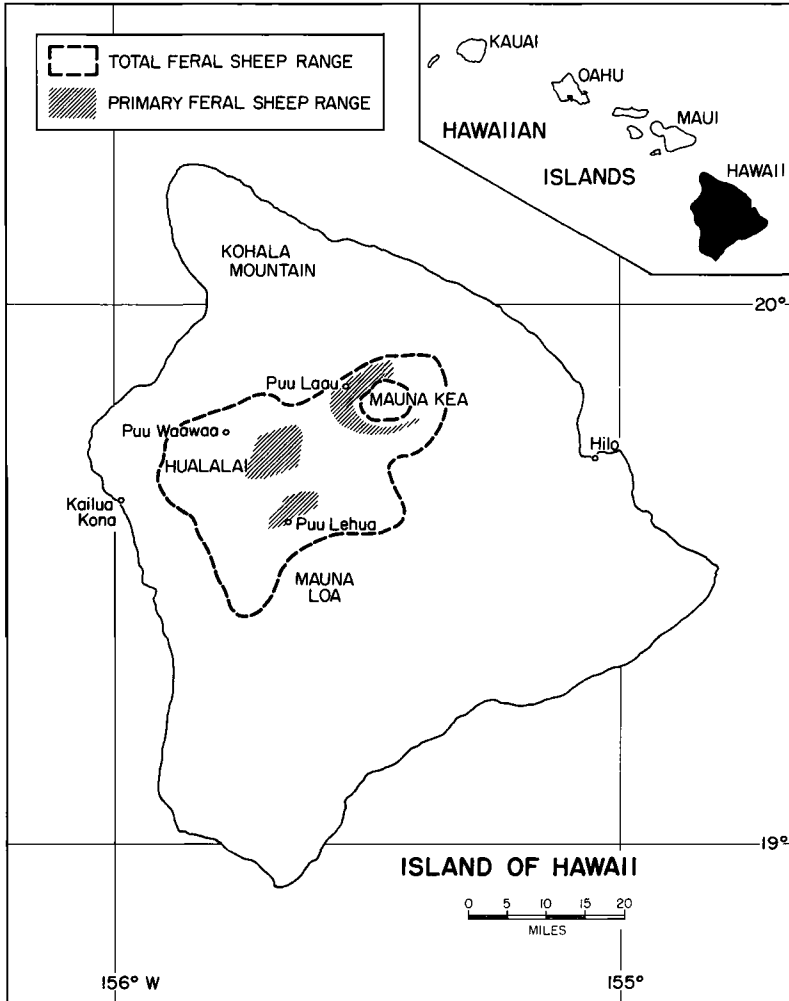


Fig. 1. A map of feral sheep distribution on the island of Hawaii.

RESULTS

Four of the 10 species of birds studied on Hawaii did not incorporate sheep wool in nest construction when it was available (Table 1). All four birds build simple nests of coarse grasses that are usually without lining. The Skylark (*Alauda arvensis*) is a ground nesting bird that digs a shallow depression it lines with grasses, and thus has little need for wool as a nesting material. The Melodious Laughing-thrush (*Garrulax canorus*) builds either a flattened nest on the ground composed of interwoven grasses and large leaves, or one composed of coarse grasses interwoven to form a high bowl with compact sides when nesting in trees (van Riper 1973). The Spotted Munia (*Lonchura punctulata*) nest is retort-shaped, composed totally of coarse grasses with a small entrance at the end of a slightly downward-directed neck (Berger 1972). The nest of the Cardinal (*Cardinalis cardinalis*) is also composed of coarse grasses and is a simple cup-shaped structure with no lining.

TABLE 1
THE AMOUNT OF SHEEP WOOL USED IN NEST CONSTRUCTION WHERE SHEEP WERE PRESENT AND ABSENT ON THE ISLAND OF HAWAII

Species	Nests where sheep were present			Nests where sheep were absent		
	Without wool	With wool	Percent with wool	Without wool	With wool	Percent with wool
Skylark	13	0	0	12	0	0
Melodious Laughing-thrush	6	0	0	7	0	0
Red-billed Leiothrix	8	1	11.1	11	0	0
Japanese White-eye	4	1	20.0	15	0	0
House Finch	46	3	6.0	46	0	0
Spotted Munia	16	0	0	17	0	0
Cardinal	2	0	0	10	0	0
Elepaio	11	31	73.8	14	8	36.4
Amakihi	48	60	55.5	96	12	11.1
Palila	10	8	44.4	18	0	0

The Red-billed Leiothrix (*Leiothrix lutea*), Japanese White-eye (*Zosterops japonica*), and House Finch (*Carpodacus mexicanus*) use wool infrequently in their nests. As the Japanese White-eye is not a common resident of the high altitude dry forests of Hawaii, I found very few nests. No nest of this species was found in the study plot at Puu Laau and thus the deletion from Table 2. Guest (1974) noted the adaptability of this bird and the numerous types of nesting material it employed. The Red-billed Leiothrix builds a semipendant nest usually woven around two branches, with the bowl formed of large leaves or bark strips. None of the nests I found on Mauna Kea contained wool, but one nest in the Puu Lehua tract of Mauna Loa did have wool incorporated between the large koa (*Acacia koa*) leaves forming the body. The House Finch builds a fairly compact open statant nest, usually composed of woven grass-heads and introduced weeds. Of the 95 nests I found, only 3 contained wool. I discussed elsewhere (1976) the lack of sheep wool in House Finch nests on Mauna Kea.

I found three species that use wool extensively in their nests. The Palila (*Psittirostra bairdii*), an endangered species found only on Mauna Kea, had wool in 22.2% of its nests. The Amakihi (*Loxops virens*), one of the two most abundant endemic birds, incorporated wool into 33.3% of its nests. The Elepaio (*Chasiempis sandwichensis*) showed the greatest usage, employing wool in 60.9% of its nests.

The use of wool in nests varied within species, depending on whether nests were

TABLE 2
COMPARISON OF WOOL INCORPORATION INTO NESTS FROM INSIDE AND OUTSIDE AN ENCLOSURE AT PUU LAU, HAWAII

Species	Number inside	Number with wool	Percent with wool	Number outside	Number with wool	Percent with wool
Skylark	2	0	—	8	0	—
Melodious Laughing-thrush	4	0	—	5	0	—
Red-billed Leiothrix	10	0	—	6	0	—
House Finch	18	0	—	20	2	10
Spotted Munia	4	0	—	15	0	—
Cardinal	1	0	—	4	0	—
Elepaio	11	9	82	8	6	75
Amakihi	33	4	12	26	10	38
Palila	18	0	—	18	8	44

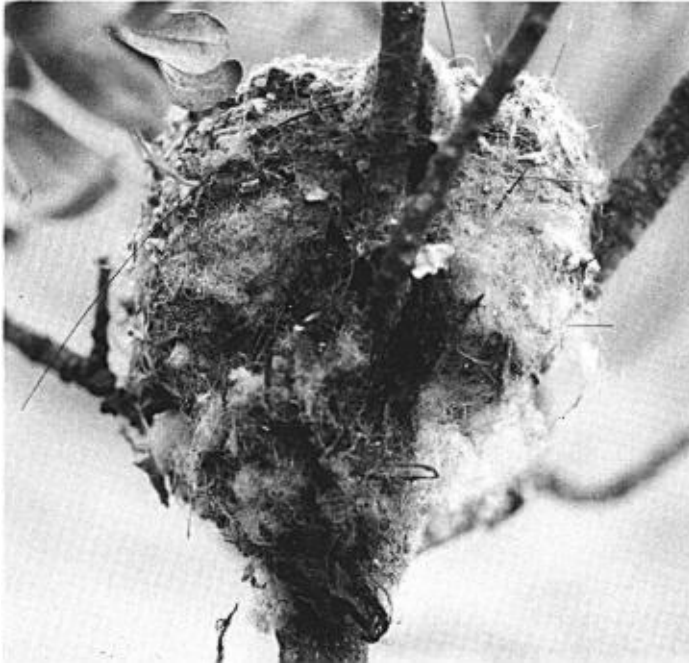


Fig. 2. An Elepaio (*Chasiempis sandwichensis*) nest containing sheep wool from Puu Laau, Hawaii.

inside or outside the sheep enclosure at Puu Laau (Table 2). All live and dead sheep were removed from the enclosure in 1967, but as wool is an enduring material some probably still remained snagged on branches, but in very small quantities when compared to the outside. No wool was present in any Melodious Laughing-thrush, Red-billed Leiothrix, Skylark, Spotted Munia, or Cardinal nest. Light usage was found in the House Finch and heavy usage again occurred in the Palila, Amakihi, and Elepaio. The difference in the utilization of wool by endemic birds inside and outside the enclosure was significant ($X_c^2 = 7.92$, $df = 1$, $P < 0.01$), but introduced birds showed no difference inside and out ($X_c^2 = 0.18$, $df = 1$, $P > 0.50$).

Sheep wool appears to be a sought-after material in two species, as both the Amakihi and Elepaio will travel outside their territories to get it for their nests. Of the 33 Amakihi nests found in the 300-acre pen, four (12%) contained wool from the

TABLE 3

THE DATE OF INTRODUCTION OF BIRD SPECIES TO HAWAII AND THE TYPE OF NEST THEY BUILD

Species	Date introduced	Type of nest construction
Skylark	1865-70	Simple, grasses
Melodious Laughing-thrush	1900-18	Simple, coarse grasses
Red-billed Leiothrix	1918-29	Complex, woven leaves and bark
Japanese White-eye	1929	Complex, intricate
House Finch	1870	Complex, woven grasses
Spotted Munia	1865	Simple, coarse grasses
Cardinal	1929-31	Simple, coarse grasses
Elepaio	Endemic	Complex, intricate
Amakihi	Endemic	Complex, woven grasses
Palila	Endemic	Complex, woven grasses

outside. Wool is a preferred nesting material for the Elepaio as 82% of the nests I found within the fenced area contained some. One nest near the center of the enclosure had a large amount of wool, meaning the bird had to fly at least 400 m to obtain it.

DISCUSSION

The use of wool in nest construction by birds in Hawaii appears to be determined by how intricate a nest they build (Table 3). Significant differences existed in the use of wool among those birds that build intricate nests and the four species that build simple nests of only woven grasses, twigs, or leaves ($X_c^2 = 26.91, df = 1, P < 0.001$). The four species that do not use wool all build rather simple nests of coarse materials, whereas those birds that exhibit some use of sheep wool all build a slightly more complex structure. The simple nest of the Cardinal is an example in which coarse grasses are woven loosely together and the binding quality of wool is not needed. The complex nest of the Elepaio sometimes takes 2 weeks to build, and it has much wool woven into the body (Fig. 2).

As sheep are such a recent addition to Hawaii, it is interesting to find the three species utilizing wool to the greatest extent are all native. Endemic species use sheep wool with much greater frequency than do exotic species, and the differences in utilization are significant: in the presence ($X_c^2 = 73.38, df = 1, P < 0.001$) and absence ($X_c^2 = 15.23, df = 1, P < 0.001$) of sheep. The Amakihi and Palila both use approximately the same percentage of wool, and both build standing nests, with the outside composed of smaller woven grasses and a separate lining of fine rootlets or lichen (see Berger 1972). Of all the species examined, the Elepaio builds the most complex nest and also exhibits the greatest preference for wool. Frings (1968) found that the Elepaio normally uses large amounts of spider web to hold the nest together. When wool is available the Elepaio apparently uses this more and spider web less.

Birds apparently select wool as a nesting material for two main reasons. First, in many places wool is readily available. In habitats that have been heavily grazed, such as tree line on Mauna Kea, I found that a greater percentage of nests contain wool than where ground cover is available. Secondly, the lightness and binding quality of wool makes it easy to manipulate.

The wool used in nest construction is gathered from two different sources. As the sheep move through the vegetation their wool catches on branches, is pulled off in tufts, and birds collect what remains hanging. A second source is dried skins, either left by hunters or from dead animals. An example of this occurred in April 1974 when I watched a male Elepaio frequenting a sheep head I had placed in a wire fence. The bird first searched for insects, then picked wool from the head and carried it off to the nest site.

The amount of wool a species uses in nest construction varies from only a small piece, as in the House Finch (van Riper 1976), to almost the entire nest, as in the Elepaio (Fig. 2). Wool is used only in the body of the nest, never in the lining. The tufts are poked into the exterior and, except by the Elepaio, are not spread or woven around other materials.

Some birds use wool if it is immediately available, but only the Elepaio and Amakihi will fly any distance for it. Pettingill (1971) found that the Tree Swallow (*Iridoprocne bicolor*) may sometimes fly several miles to a chicken farm to obtain the much-preferred white feathers. In 1970 on Hualalai where sheep were present, every

nest (12) I found contained wool. Only one-half mile away, in a pasture that excluded sheep, not a single nest had wool. On Mauna Kea in 1974, a color-banded pair of Amakihi had no wool in their first nest. They renested 91 m away above an old sheep skin, and their second nest had a considerable amount of wool.

It is interesting to note that within the last 150 years the native bird species of Hawaii have adapted to using sheep wool as a nesting material, but the newly introduced exotic species have not (see Table 3). Although used in parts of Hawaii, to most bird species wool is not a sought-after nesting material.

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