

Arctic Warbler Ko-mushikui (Jpn) *Phylloscopus borealis* Kamchatka Leaf Warbler Oh-mushikui (Jpn) *P. examinandus* Japanese Leaf Warbler Meboso-mushikui (Jpn) *P. xanthodryas*

Morphology and classification

Classification: Passeriformes Phylloscopidae

Recent molecular phylogeny has established the family of Phylloscopidae to which the leaf warblers were moved from conventional Sylviidae (Parkin & Knox 2010, Terry et al. 2010).

The Arctic Warbler (*Phylloscopus borealis*) was described by Blasius in 1858 and have been treated as a polytypic species with 3-7 subspecies. However, the author and his coworkers studied the molecular phylogeny, external morphology and vocalization of this species in almost all the populations of the breeding range, and proposed that *P. borealis* should be divided into the following three independent species (Saitoh et al. 2008, 2010, Alström et al. 2011, Saitoh et al. 2012):

- Arctic Warbler (Ko-mushikui) *P. borealis*
- Kamchatka Leaf Warbler (Oh-mushikui) *P. examinandus*
- Japanese Leaf Warbler (Meboso-mushikui) *P. xanthodryas*

Hereafter, the species names are used according to this classification. Our proposition is based on that these leaf warblers are distinguished into three different groups in vocalization, molecular phylogeny and morphology (Saitoh 2009). For example, three types of songs and calls have been known for the leaf warblers. The DNA analysis suggested that they diverged in the old period of 1.9-2.5 million years ago (from late Pliocene to early Pleistocene epochs). The discriminant analysis showed that it was possible to distinguish between them with 90% accuracy based on the morphological measurements.

In Japan, Japanese Leaf Warblers breed in the subalpine zone south of Honshu (the largest main island) and Kamchatka Leaf Warblers breed in the Shiretoko Peninsula, Hokkaido (the northernmost main island) (Fig. 1). The third species of the Arctic Warbler is confirmed to pass Japan in the migration season of autumn (Saitoh 2004).



Photo 1. Arctic Warbler

Wing length: 65.9mm (63.6–68.1) n = 18
 Tail length: 47.3mm (41.5–52.2) n = 18
 Tarsus length: 18.6mm (17.5–20.6) n = 16
 Length, P10-PC: -1.2mm (-3.4– 0.9) n = 8
 Weight: 9.6g (8.5–11.5) n = 17



Photo 2. Kamchatka Leaf Warbler

Wing length: 66.3mm (60.3–71.7) n = 16
 Tail length: 49.1mm (46.3–52.3) n = 16
 Tarsus length: 20.0mm (18.5–21.3) n = 15
 Length, P10-PC: 0.1mm (-4.0–3.0) n = 16
 Weight: 11.1g (9.0–13.0) n = 17



Photo 3. Japanese Leaf Warbler

Wing length: 70.8mm (68.6–75.5) n = 45
 Tail length: 51.3mm (45.0–54.6) n = 45
 Tarsus length: 20.3mm (18.6–21.8) n = 45
 Length, P10-PC: 2.7mm (0.4–4.9) n = 37
 Weight: 11.9g (9.8–13.0) n = 39

The measurements of male adults are based on Saitoh et al. 2008. Those of Arctic Warblers include the subspecies *Phylloscopus borealis keniccottii*. The length of P10-PC indicates a difference between the length of the outermost primary flight feather (P10) and the longest feather of the primary wing covert.

Appearance:

Males and females are similar in plumage coloration. Japanese Leaf Warblers are olive-colored and most strongly tinged with yellow on the upper- and underparts among the three

similar species. Arctic Warblers are grayish green brown lacking yellow tint on the upperpart and strongly tinged with white on the underpart. Kamchatka Leaf Warblers are somewhere in-between in plumage coloration. The plumage coloration alone is not sufficient to distinguish between the three species because it has individual and regional variations. If a genetic analysis is not possible, it is advisable to determine their species based on comprehensive information about vocalization (call and/or song), morphological measurements and plumage coloration.

Vocalization:

Arctic Warblers sing a simple song in a thick voice repeatedly like "Jee-jee-jee-jee-jee-jee". Kamchatka Leaf Warblers sing a song with the three syllables of "Jijir-jijir" in a thick voice. Japanese Leaf Warblers warble "Cho-cho-cho-ri" with an accent in the second syllable in a thick voice, which is memorized (mnemonics) as "Zenitori, zenitori (money collector)" in Japanese.

Distribution and Habitat

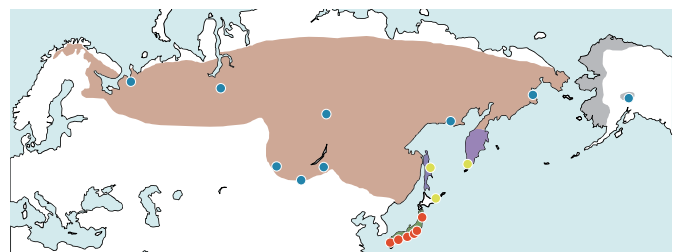


Fig. 1. Breeding distributions of the three species. Circles show the study sites of the species (phylogenetic groups). Blue: Arctic Warblers, Yellow: Kamchatka Leaf Warblers, Red: Japanese Leaf Warblers. The background coloration shows the former demarcation of the subspecies. Modified from Saitoh et al. 2010.

Distribution:

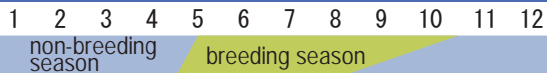
Japanese Leaf Warblers breed in Honshu, Shikoku and Kyushu (three of the main four islands of Japan). Kamchatka Leaf Warblers breed in the Far East regions in Kamchatka, Sakhalin as well as Hokkaido, Japan. The breeding range of Kamchatka Leaf Warblers in Japan is limited to the Shiretoko Peninsula in the northeastern Hokkaido (Saitoh et al. 2010). This population is important as the southernmost population of this species in terms of conservation biology. Arctic Warblers widely breed in the Arctic regions from Scandinavia to western Alaska.

The three species winter in Japan (the Yaeyama Islands), Taiwan, the Philippines, Southeast Asia and Indonesia. There is detailed information about the wintering distribution of each species in Ticehurst (1938), but no in-depth study with a DNA analysis has been carried out in their wintering grounds.

Habitat of breeding area:

In Japan, Japanese Leaf Warblers breed in the forests of the subalpine conifer zone (*Abies mariesii* and *Tsuga diversifolia*) at an altitude of 1,500-2,500m, and the alpine zone (*Pinus pumila*, *Betula ermanii* and *Alnus maximowiczii*). Kamchatka Leaf Warblers also breed in the birch-dwarf pine zone of the sub-alpine forest line in the Shiretoko Peninsula. In Sakhalin and Kamchatka, however, Kamchatka Leaf Warblers commonly occur in broad-leaved deciduous forests (willows and birches) along a river in the lowlands as well. In the Eurasian Continent, Arctic Warblers are found in the mixed shrubs of conifers and broad-leaved trees of the Taiga zone, but they prefer the waterside with willows and birches (Cramp 1992).

Life history



Breeding system:

The three species are said to be monogamous, but some Arctic Warbler males are synchronous polygamists (males that have two nests with nestlings simultaneously) in Finland and the Yamal Peninsula, Russia (Cramp 1992). In Japan, some Japanese Leaf Warbler males are also suspected of being polygamous (Haneda & Kiuchi 1969).

Territory:

Japanese Leaf Warbler males establish a territory and defend it by singing within it. The density of male territories were estimated to be 103.3 per 1km² in Japan.

Nest:

Japanese Leaf Warblers usually build a nest in a mossy hollow, a space between the roots of a tree, at the base of *Sasa* spp. (bamboo grass) and in a gap in a pile of fallen twigs on the ground. The nest is globe-shaped and has an entrance on the side. They use mosses for the exterior and root rhizomorph, fine roots and animal fur for the inner cup.

Egg:

The clutch size is 4-5 eggs in Japanese Leaf Warblers. The egg has minute flecks on a white ground. The clutch size is 6-7 eggs in Arctic Warblers. In Alaskan population of Arctic Warblers (subspecies, *P. b. kennicotti*), on the other hand, the clutch size is 5.9 eggs on average (range = 5-7 eggs, n = 18) (Ring et al. 2005).

Nestling period:

In Japanese Leaf Warblers, females alone incubate their eggs for 12-13 days. Both males and females feed the young. The nestlings are brood over by the female for a few days, and fledged 13-14 days after hatching (Haneda & Kiuchi 1969).

Natural enemy:

Japanese Leaf Warblers are frequently parasitized by the Oriental Cuckoo (*Cuculus optatus*). A study showed that 40% of Japanese Leaf Warbler nests were parasitized by this cuckoo (Haneda & Kiuchi 1969). They often suffer the nest predation of snakes as well, but the author has recorded a marten (*Martes melampus*) preying on Japanese Leaf Warbler nestlings on video.

Migration:

Japanese Leaf Warblers arrive at the breeding grounds around early to mid-May and leave there from August to October. Kamchatka Leaf Warblers pass through Japan to the breeding grounds from mid-May to early June and return to the wintering grounds from mid-August to early October. Arctic Warblers also travel through Japan during the autumn migration season, but their number is smaller than those of the other two leaf warblers (Saitoh 2004).

Diet and foraging behavior

The diet of the three species consists primarily of insects, which is responsible for the Japanese name of the *Phylloscopus* warblers "mushikui (insect eater)". In summer, Japanese Leaf Warblers principally consume invertebrates such as spiders, the larvae and imagoes of beetles, flies, butterflies and cicadas. In late autumn, on the other hand, they also feed off the fruits from plants (Kiyosu 1952). In Alaska, the staple diet of Arctic Warblers are larvae and imagoes of mosquitoes (Ring et al. 2005).

Japanese Leaf Warblers feed in the understory of a coniferous forest, such as bushes and shrubs. In a birch forest, on the other hand, they also use the overstory as a foraging site. In the alpine zone, they use the broad-leaved trees scattered in a coniferous forest, and

capture insects perched in the tree or flying around it by gleaning or jumping at the underside of leaves and twigs, as they move from a lower branch to another. (Nakamura & Nakamura 1995).

Topics of ecology, behavior and conservation

● Interesting behavior

Japanese Leaf Warblers sing for an exceptionally long time as a summer resident, which extends from late May to early October. This is a remarkable breeding behavior because passerines in general stop singing or rarely sing in the late breeding period. However, the reasons behind their long-term singing are not clear yet. When males show a courtship display moving the wing and tail up and down, they sometimes pick up mosses or twigs from the ground in the bill and throw them at females (Nakamura 1979). I saw a similar behavior, however, when I was playing back their song to capture them for a study. I was very surprised to see a male pick up and throw a fallen leaf at the replaying speaker.

Literature

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More than ten years have passed since I started to study Japanese Leaf Warblers in graduate school. I owe it to the warblers that I could visit Russia, Mongolia and various areas of Japan and make many acquaintances. I would like to continue phylogeographic studies of warblers and other taxonomical groups, while respecting the connections of people and communities. saito@yamashina.or.jp