

The Skull of *Regulus regulus*, with Some Remarks on the Taxonomic Status of Regulidae

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Regulus which includes the Goldcrest, Firecrest and Kinglets is a small genus, with all the four known species distributed widely in temperate Eurasia and North America as far south as high mountains of Formosa. This genus, together with its possible relatives *Leptopoecile* and *Lophobasileus*, was once referred to Paridae (Regulinae) by HARTERT (1907, p. 394), HELLMAYR (1903, p. 2), and some earlier workers.

Recent taxonomists, however, have suggested that it should have the real affinity with Sylviinae. To quote from WITHERBY *et al.* (1938, p. 314), "...it is difficult to see the ground for this view [association with Paridae], as they [Regulidae] do not agree with the tits in their skull form, limbs, or any other distinctive structural features; their breeding-habits also differ. ...[From Sylviidae] they differ in no important particular..." (see also RIDGWAY, 1904, p. 699). Although WETMORE (1951) has retained Regulidae in his classification, some of American ornithologists¹⁾ have placed *Regulus* in Sylviinae, and this arrangement has also been followed in the 1958 hand-list of Japanese birds. MAYR and AMADON (1951, p. 19) placed it in the tribe Sylviini (Sylviinae), assuring of a close relationship between *Regulus* and *Phylloscopus*.

Apart from taxonomic arguments based upon general consideration, so little has been written on the internal anatomy of regulids (SHUFELDT, 1889a, b). In this article are presented some accounts of the skull of *Regulus regulus*, together with remarks on the taxonomic status of this group.

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Description

The following description is based on four adult skulls as well as fragments from two other skulls:

1) MAYR and AMADON, 1951; MAYR and GREENWAY, 1956; VAURIE, 1959.

Skull aegithognathous. Basitemporal plate subtrapezoid, three times as wide as long, with front margin a little produced at the middle and fused with parasphenoidal rostrum save a small apical portion; basipterygoid process entirely absent; parasphenoidal rostrum short. Foramen magnum cordiform; a pair of well-marked grooves on the dorsal rim of occipital foramen, each groove

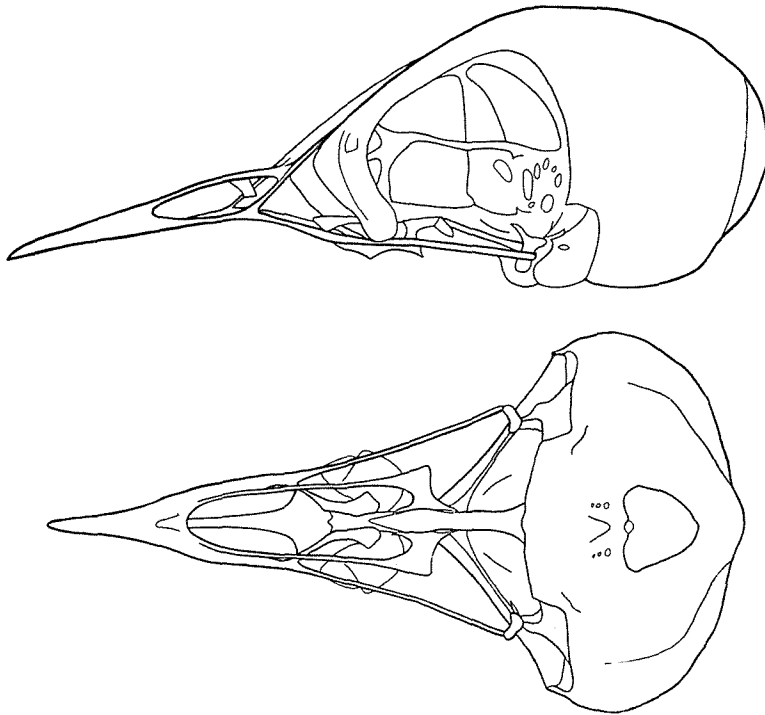


Fig. 1. *Regulus regulus* (LINNÉ); left lateral view of the skull, somewhat oblique (upper), and ventral view of the same (lower).

terminating in a small aperture; occipital condyle very small and spherical; lamboidal ridge rather obtuse; cerebellar dome well convex, forming a swelling, bounded on each side by supraoccipital fossa, which is not sharply defined; cerebral dome wide (wider than long) and gently convex, with the roof marked by a median groove; lateral groove of "Sylvian fissure" very faintly indicated; interorbital region of frontal narrow, with a shallow median groove.

Tympanic cavity moderately developed, more or less shallow, with a sub-crescent aperture of opening; free edge running from processus articularis squamosi meeting at a sharp angle with the extension of the free edge of lateral occipital wing and not merging into the latter, which curves forwards as a well

defined ridge and joins postorbital process; postorbital process very short; temporal fossa wholly obliterated; processus zygomaticus squamosi prominent; processus articularis squamosi rather indistinct; antorbital plate narrow, with lateral border rather 'truncated' than 'winged'; ectethmoid foramen single; lachrymal fused, not free; interorbital septum largely fenestrated, remaining only a very slender bar in the middle.

Premaxilla slender and of moderate length, slightly decurved in front; dentary process of premaxilla fairly broad, feebly bending outwards; nasal process narrow. Nasal holorhinal, with an oblong-oval aperture of narial orifice; descending process of nasal very narrow; nasal hinge indistinct; ossified nasal septum composed of a thin sheet of fragile rudimentary bone, which protrudes vertically from the nasal process at about one-third from the posterior end. Mandible flexible and slightly bowed downwards, with narrow symphyseal region and narrow lateral vacuity.

Maxilla decidedly small and ill-defined, and not perforated by small pneumatic foramina; maxillo-palatine process fairly long and slender, extending obliquely backwards on the ventral side of the free end of vomer for nearly a half the length; pedicel very slender; pedate free end forming a thin flat plate of oblong bone, with the apex slightly hooked outwards. Anterior palatal

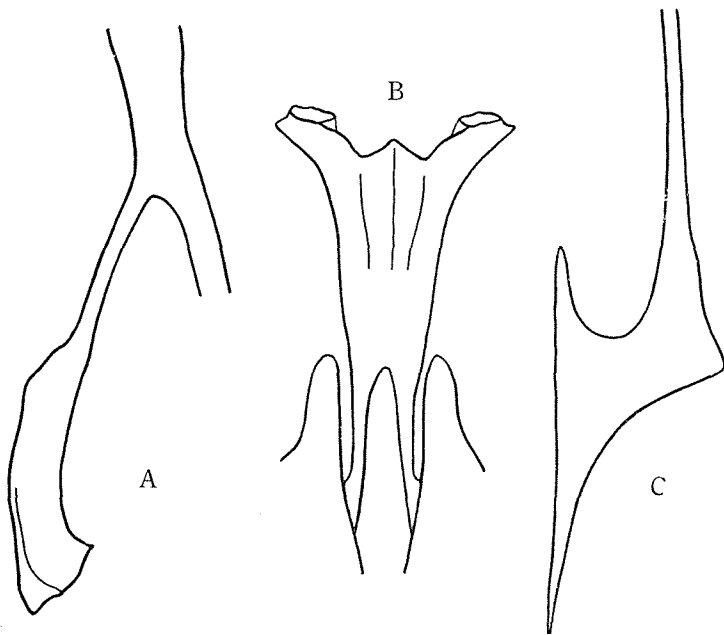


Fig. 2. *Regulus regulus* (LINNÉ).—A. Left maxillo-palatine, ventral view.
—B. Vomer, ventral view.—C. Left palatine, ventral view.

vacuity widely open in front of maxillo-palatines. Jugal and quadrato-jugal slender and nearly straight. Vomer broad, rather short and robust, dilated anteriorly, more or less trough-shaped in dorsal aspect, and with a well defined median ventral keel; front margin deeply notched on either side of median line in front, with lateral angles well produced into a pair of delicate quadrangular processes, each twisted laterally towards the apex which is dilated into a cup; posterior part deeply cleft on the median line for more than a half the length. Interpalatine process long and conspicuous, with the apex pointed and slightly turned up; external lamina narrow, with the postero-external angle either obtuse or subtruncated at apex; prepalatine bar long, slender and closely adjacent to dentary process of premaxilla for about anterior two-fifths of its full length. Pterygoid nearly straight, compressed and relatively short, with the anterior end hooked but not dilated into laminar plate; quadrate relatively small, with moderately developed articular processes.

The following measurements were taken from skulls. Average measurements and ranges are in millimetres. (For method employed, see FISHER, 1944, p. 272.)

Skull length, 23.3 (22.4-23.5); skull width (greatest width of cranium), 12.0 (11.7-12.0); basal length (from ventral lip of foramen magnum to tip of bill), 20.2 (19.4-20.4); cranial length, 13.3 (12.9-13.5); cranial height (from plane of basitemporal plate), 8.5 (8.3-8.7); postorbital width, 10.1 (9.7-10.2); interorbital width (narrowest width of interorbital region of frontal), 1.5 (1.5-1.7); premaxillary length, 9.7 (9.4-9.9); premaxillary anterior to nares, 4.6 (4.4-4.7); bill depth, 1.1 (1.0-1.2); bill width, 1.9 (1.8-1.9); narial length, 4.3 (4.1-4.4); mandibular length, 16.6 (16.0-16.8); symphyseal length, 3.7 (3.7-3.8).

Taxonomic Remarks

The skull of *Regulus* may be distinguished from those of the other sylviine genera by the following points: ossified nasal septum present; maxillo-palatine process long and slender, with pedate free end thin, oblong and neither inflated nor pneumatic; vomer broad and short, with a trifurcate front margin and widely spaced posterior limbs; interpalatine process prominent; external lamina of palatine narrow, with the postero-external angle more or less obtuse; an indistinct nasal hinge present; descending process of nasal slender; external aperture of tympanic cavity narrow, with small postorbital process and developed wing of exoccipital. Besides these there are other minor differences too subtle to be constant. The characteristics given above will, however, be sufficient to separate *Regulus* from the remaining genera of Sylviinae, though the diagnosis is based only on *R. regulus*.

In all the six sylviine genera examined by the writer²⁾, the ossified nasal

2) The following species were available for comparison: *Phylloscopus borealis*, *P. occipitalis*, *P. ijimae*, *Cettia diphone*, *Urosphena squameiceps* (damaged skull), *Locustella ochotensis*, *L. lanceolata*, *Acrocephalus arundinaceus*, *A. bistrigiceps* and *Cisticola juncidis*.

septum is not represented even by a vestige. Maxillo-palatine processes are more or less pneumatic or spongy in character, especially so in *Cettia* and *Acrocephalus*. In this subfamily, as here represented, these bones tend to be rather variable in their configuration. They are short and very much dilated distally, having the free distal end usually inflated to enclose air-cell. Only in *Locustella* the free end of maxillo-palatine is flat and lacks air-pocket. It may well be noted that the vomer of the sylviids has been reduced to a very small bone. Here, the bone is represented by a thin oblong plate, which is narrow, much shorter in length and with decidedly shorter limbs. It is as a rule delicately dentate (subject to a certain variation) along the front margin but without any "horns" such as met with in *Regulus*.

Regulus may be different from the sylviids in the shape of palatine. In the latter group, external lamina of palatine is spacious, with prominent postero-external angles, whereas the interpalatine process is small. The nasal hinge is perfectly effaced. Some difference may also be found in the relative size of the descending process of nasal, which is much wider in the sylviids. Although there remains some doubt about the taxonomic value of this bone, the character was once claimed by LUCAS (1889, p. 173) to be very much useful in thrushes, Miminae and wrens. Sylviinae may agree with *Regulus* in the form of the occipital, squamosal and ethmoidal regions of the skull and the tympanic cavity, but in one point the former is different significantly from the latter. In the former group the postorbital process is prominent (rather short in *Locustella*).

Despite great similarity in external structure, the subfamily Sylviinae is no doubt a most heterogeneous group in the large assemblage of thrushes-flycatchers. The six genera of the sylviids examined are variable to some extent in the characters of the skull. They somewhat vary in the configuration of maxillo-palatines and vomer, a character which is very stable in some other groups, e.g. Turdinae. Hence the warblers may be considered possibly to be subdivided into two or more. There is, however, scarcely any doubt about the arrangement to place *Regulus* in a group, either as a subfamily or as a family, quite distinct from all the other warblers. This may be known from the view that some of the discriminative characters are not of species or genus but of higher categories.

The validity of the arrangement may further be supplemented by characters other than those shown by the skull. Of the four main characters enumerated by RIPLEY (1952, p. 3) in discriminating subfamilies within Muscicapidae, two features (moult and tarsus) are available to distinguish *Regulus* from Sylviinae and one (juvenile plumage) may be common between the two. Double moult, a partial or complete spring moult in addition to the complete autumn moult, is far prevalent in Sylviinae, whereas only a single annual moult takes place in *Regulus*. Tarsus is primarily scutellate, either distinctly or indistinctly, in Sylviinae, but booted in *Regulus* (quasi-booted in *Leptopoecile*). It has been noted, however, that there is a tendency towards booted tarsi in the former group. The fourth character of RIPLEY, the rictal bristles, is most ambiguous,

and may not have so a definite value. These bristles are present in both the groups as well as the other related ones. *Regulus* also possesses a single minute stiff feather covering each nostril (except *R. calendula*). In addition to these, the differences in plumage and behaviour between the two sexes and between adult and young are more pronounced in *Regulus* than in Sylviinae.

It should be noted that even these 'generalized' characters, now of frequent use, are more or less confluent and not so perfectly diagnostic of the 'groups'. There usually occur some transitional forms among them. Such 'generalized' characters are, however, still useful in recognizing natural groups, and the occurrence of exceptional forms may better be regarded as the results of rapid diversification. In some cases, the presence of such intermediates may indicate the affinity between certain two groups, but in other cases, it may be a mere result of superficial convergence. It seems to the writer that *Regulus* has hitherto been related to Sylviinae on the basis of certain unreliable characters. So far as indicated by the features discussed on the foregoing pages, *Regulus* may be related to Sylviinae but distantly, and the relationship between them may not be so close as has generally been understood up to the present. In short, Regulidae may better be retained as an independent subfamily under the present circumstances of avian classification.

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