

# SACRAL FUSIONS IN SOME NEOTROPICAL *RANA*

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**ABSTRACT.** — Sacral-presacral fusion occurs with a higher incidence in the frogs of the *Rana palmipes* group than in any other species group of new world *Rana*.

The significance of sacral fusions in the anurans has not been clearly understood. Noble (1931) and subsequently other authors have concluded that there was no functional significance. However, these fusions involved, for the most part, fusions of presacral vertebrae or of the sacrum and the coecyx (urostyle).

Holman (1963) has recently studied a large and variable series of anurans (Ascaphidae, 1; Discoglossidae, 2; Pipidae, 3; Rhinophrynidae, 5; Pelobatidae, 36; Leptodactylidae, 16; Bufonidae, 148; Atelopodidae, 2; Centrolenidae, 1; Hylidae, 182; Microhylidae, 13; and Ranidae 119.) He found that such fusions as well as those which were obviously aberrant were exceptional cases—not the rule.

In this report I will concern myself with the American *Rana*. The material studied includes the following:

*Rana areolata* 45, *R. aurora* 2, *R. boylei* 4, *R. capito* 2, *R. cascadae* 8, *R. catesbeiana* 48, *R. clamitans* 25, *R. gryllio* 15, *R. heckscheri* 5, *R. maculata krukoffi* 1, *R. m. maculata* 6 (by x-ray), *R. palmipes* 24, *R. palustris* 22, *R. pipiens pipiens* 60, *R. p. sphenoccephala* 25, *R. p. berlanderi* 4, *Rana pipiens subsp.* (Mexico) 10, *R. pretiosa luteiventris* 8, *R. pustulosa* 7, *R. septentrionalis* 1, *R. sier-*

*ramadrensis* 1, *R. sylvatica* 8, *R. tarahumarae* 1, *R. warschewitschii* 16. J. Alan Holman (in litt.) has told me of three additional *R. palmipes* with a presacral fusion.

Zweifel (1955:210) studied several *Rana* skeletons in the course of his study of the *Rana boylei* group. He studied sacral of *Rana aurora* 8, *R. boylei* 28, *R. cascadae* 10, *R. muscosa* 19, *R. pipiens* 4, *R. pretiosa* 1 and *R. tarahumarae* 4.

The American *Rana* studied by Holman (loc. cit.) were: *R. areolata* 2, *R. aurora* 1, *R. boylei* 2, *R. capito* 1, *R. cascadae* 2, *R. catesbeiana* 5, *R. clamitans* 9, *R. gryllio* 4, *R. heckscheri* 3, *R. palustris* 1, *R. pipiens* 78, *R. sylvatica* 7. Thus 530 new world *Rana* are available for comment.

Of the 78 skeletons studied by Zweifel (loc. cit.) none showed a presacral-sacral fusion. This is evidenced by Zweifel's remarks concerning a postsacral fusion—" . . . [one *boylei* was] unusual in having the urostyle and sacral vertebra fused." One can be fairly sure that if a presacral-sacral fusion had been evident Zweifel would have commented on it.

The species groups of neotropical and to a lesser extent nearctic *Rana* have been outlined by Zweifel (1955, 1956, 1957, and 1964) and myself (MS). The *Rana palmipes* group includes *R. maculata* subsp., *R. miasdis*, *R. sierramadrensis*, *R. sinaloae*, *R. palmipes* subsp., *R. taylori*, *R. vibicaria* and *R. warschewitschii* (Zweifel 1956 and 1964). The *Rana pipiens* group includes *R. dunni*, *R. megapoda*, *R. montezumae* and *R.*

*pipiens* as well as several species in the eastern United States. The *Rana catesbeiana* group is represented only by *R. catesbeiana* in the area concerned. *R. clamitans*, *R. grylio*, *R. heckscheri*, and *R. septentrionalis* are members of this group whereas *R. capito* and *R. palustris* are members of the *R. pipiens* group.

The fused sacral-presacral of *R. palmipes* is illustrated in Figure 1.

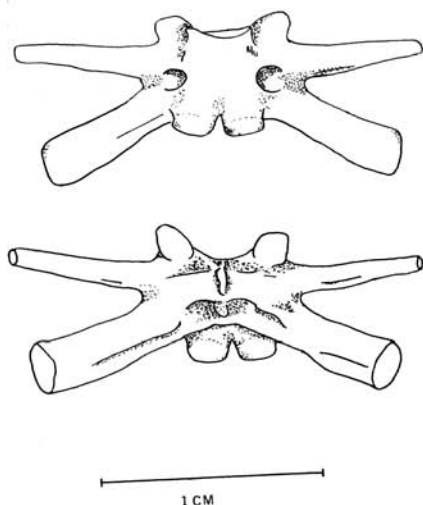


FIGURE 1.—Dorsal (A) and ventral (B) views of fused sacral-presacral vertebrae in an adult *Rana palmipes* (San Andres Tuxtla, Veracruz, Mexico.)

The fusion is symmetrical and the rule—not the exception. The data in Table 1 clearly illustrates that the frogs of the *R. palmipes* group are nearly unique in the high frequency of sacral-presacral fusion. The frogs of the *R. boylei* group also show some fusion and this might be expected as they are closely related. In the other species which showed the condition, the percentages are below 5%—in all but one case. In this instance, *R. capito*, the

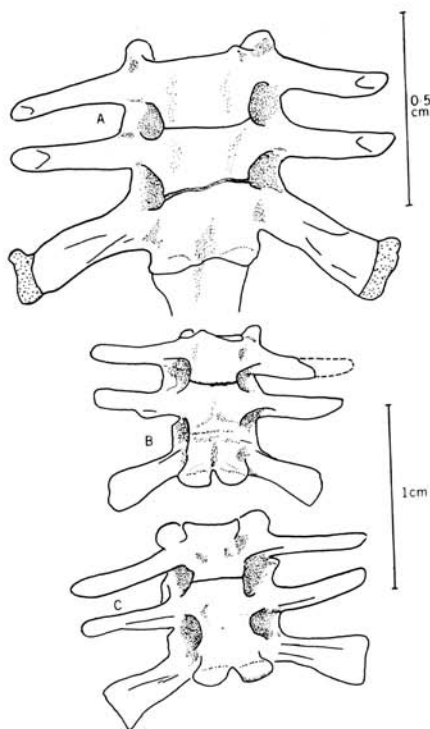


FIGURE 2.—Ventral view of posterior portion of vertebral column in *Rana pustulosa*. (A) UIMNH 32185, 52 mm snout-vent length; (B) UIMNH 32251, 73 mm snout-vent length; (C) UIMNH 40875, 85 mm snout-vent length.

data was skewed because so few individuals were seen. In the closely related *R. areolata* (considered conspecific by some workers, e.g., Conant, 1958), such fusions were not seen in a large series.

The *R. palmipes* group is morphologically very close to the *R. boylei* group, particularly the two southernmost species, *R. tarahumarae* and *R. pustulosa*. *Rana pustulosa* is superficially very much like *R. sinaloae*, the northernmost form of the *R. palmipes* group.

In one specimen of *R. tarahumarae*, a very large adult, an obvious

TABLE 1.—Incidence of sacral-presacral fusions in new world *Rana*.

Species	Number with fusion	Number examined	Percentage fused
<i>R. capito</i> .....	1	3	33.3
<i>R. clamitans</i> .....	1	34	2.9
<i>R. catesbeiana</i> .....	1	53	1.9
<i>R. maculata (krucki)</i> .....	1	1	100.0
<i>R. maculata (maculata)</i> .....	6	6	100.0
<i>R. palmipes</i> (adults).....	24	24	100.0
<i>R. pipiens</i> .....	5	179	2.8
<i>R. palustris</i> .....	1	23	4.3
<i>R. tarahumarae</i> .....	$\frac{1}{2}$ <sup>1</sup>	5	10.0
<i>R. pustulosa</i> .....	2	7	28.6 <sup>2</sup>
<i>R. sierramadrensis</i> .....	1	1	100.0
<i>R. warschewitschii</i> .....	16	16	100.0

<sup>1</sup> Fused on one side only—see text.<sup>2</sup> Fused only in old adults—see text.

fusion was seen on one side of the sacral-presacral suture whereas it appeared that the other side was not fused. Zweifel (loc. cit.) found no fusions in his specimens. The seven *R. pustulosa* studied represented three age classes—young (52-53 mm snout-vent), intermediate (73-74 mm snout-vent), and large adults (81-85 mm snout-vent). The fusion is clearly an ontogenetic characteristic. In the youngest individuals (Fig. 2) a broad suture is in evidence and the sacral vertebra moves readily in respect to the presacral. In those specimens of middle age where the suture is still evidence although there is some fusion, it was possible to break the bones apart with relative ease. The older specimens showed no evidence of a suture and fusion is complete. In those frogs of middle age, when the suture was broken the diplasiocoelous condition was still clearly evident. It is not known if the fusion is a result of building up of the bone on the

surface or a fusion at all surfaces. There seemed to be a deposition of osseous material anterior to and posterior to the suture in the middle aged frogs.

In *Rana palmipes*, specimens 60 mm in snout-vent length showed complete fusion (Fig. 3) as did all larger individuals examined (25 specimens) whereas smaller individuals (ca. 43 mm) showed a non-fused condition. It seems likely, although sufficient numbers of specimens are not available to test the hypothesis, that in all species of the *Rana palmipes* group the sacral-presacral fusion is an ontogenetic characteristic and that this feature expresses itself early in the ontogeny of the members of this group and later in the members of other groups.

That this may well be the case in most new world *Rana* is strongly suggested by the remarks of Holman (loc. cit.) who noted the very high incidence of fusion in *Rana catesbeiana* from a Pleistocene locality in

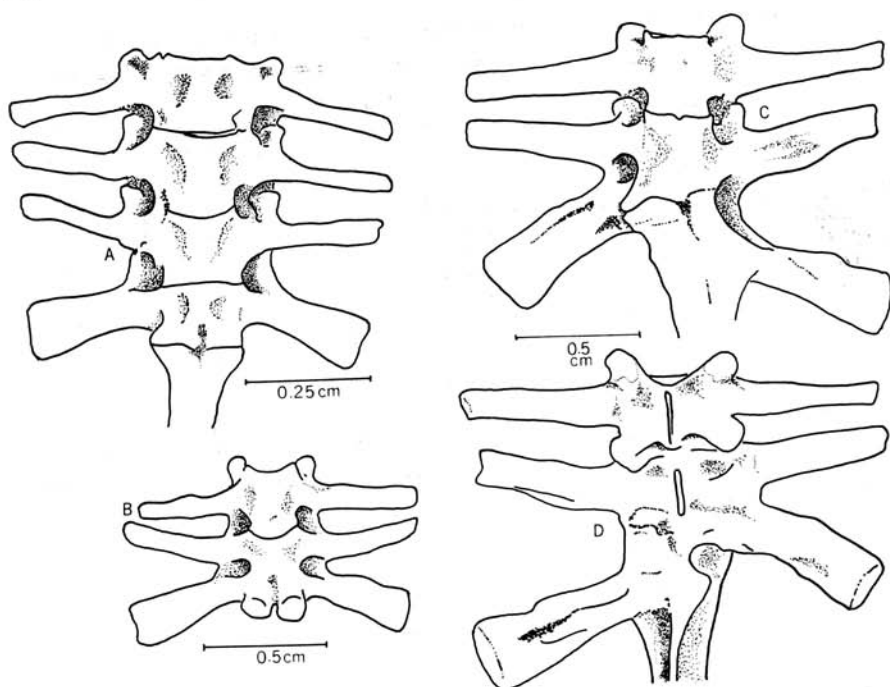


FIGURE 3.—Ontogenetic fusion of sacral and presacral vertebrae in *Rana palmipes*. (A) UIMNH 51175, 43 mm snout-vent; (B) UIMNH 9851, 60 mm snout-vent; (C) UIMNH 9857, 90 mm snout-vent, ventral view illustrating anomalous sacral diapophysis; (D) dorsal view of C.

Florida. Dr. Holman has kindly permitted me to examine the specimens and judging from the sizes of certain bones, the fossils represent, in nearly every case, individuals of snout-vent measurements of about 200 mm (8 inches) or more.

However, in the cases of fossils of *Rana pipiens* in which the fused condition is seen, the percentages of fusion are much lower in cases where adequate samples are available and correspond favorably to the percentages obtained from samples of Recent specimens. Also, the fossil *R. pipiens* are not extra large frogs. In the case of this species, it seems more likely that the fusion results from a similar or the same phenomenon

which produces it in Recent frogs of average or moderate size.

The functional significance of the sacral-presacral fusion in frogs is not clearly apparent. In mammals several vertebrae fuse to form the sacrum and in birds the synsacrum serves for greater stability and motility.

If the evidence from the fossil record is real as well as apparent, this, coupled with the ontogenetic development of the sacral fusion, would seem to indicate that the condition arises as an adaptation to the stresses created by increased weight and size of older specimens. Greater forces would be applied, in jumping and landing, to the sacrum in larger

individuals than in smaller specimens of that species. Thus a larger and more rigid sacrum would provide a pivot in an area of relatively little restricted movement. Whitting (1964) has illustrated some of the limits to movement in the functional unit composed of the vertebral column, urostyle and ilia. Fusion of some vertebrae to each other or fusion of the sacrum to the urostyle would reduce some of this movement and lend to greater stability. Fusion of the sacral and presacral vertebrae seems to be the only means for a frog with cylindrical sacral diapophyses to approach the condition of a frog with expanded diapophyses. Of interest is the fact that very few ranid frogs exhibit expanded diapophyses.

#### SUMMARY

The sacral-presacral fusion as defined by Holman (1963) occurs with a higher incidence in the frogs of the *Rana palmipes* group than in any other species group of new world *Rana*. It is seen only as a rarity in the *pipiens*, *catesbeiana*, *sylvatica* or *auroa* species groups or in very old specimens (only fossils as far as is known at this time). The fusion occurs as an ontogenetic feature in the frogs of the *boylei* and *palmipes* groups and is more characteristic of the Mexican species of the former group than the Pacific coast species of that group. Use of this feature in creating supraspecific taxa (e.g. *Anchylorana*) as Taylor (1942) did is not to be advised.

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