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<th>Unmasking <em>Rana okinavana</em> Boettger, 1895 from the Ryukyus, Japan (Amphibia: Anura: Ranidae)</th>
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*Kyoto University*
Unmasking *Rana okinavana* Boettger, 1895 from the Ryukyus, Japan (Amphibia: Anura: Ranidae)

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Examination of the lectotype and a paralectotype of *Rana okinavana* Boettger, 1895 revealed that the species is not a brown frog of the subgenus *Rana*, occurring in the middle group of the Ryukyu Archipelago, but is identical with a frog of the subgenus *Nidirana* from the southern group of the Archipelago and Taiwan, now called *R. psaltes* Kuramoto, 1985. The type locality of *R. okinavana* given in the original description, Okinawa of the middle Ryukyus, is highly doubtful and should be somewhere in the Yaeyama Islands of the southern Ryukyus. The name *R. psaltes* is relegated to a subjective junior synonym of *R. okinavana* Boettger, 1895, while the brown frog of the subgenus *Rana* from the northern Ryukyus requires a replacement name.

**Key words:** brown frog, *Nidirana*, Okinawa Island, synonym, taxonomy, Yaeyama Islands

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**INTRODUCTION**

The Ryukyu Archipelago is geographically split into northern (Osumi and Tokara Is.), middle (Amami and Okinawa Is.), and southern (Miyako and Yaeyama Is.) groups (Ota, 1998), and each of these island groups exhibits its own high endemism in biota. The amphibian fauna of the archipelago has been well studied (e.g., Inger, 1947; Kuramoto, 1979; Toyama, 2003), but there still remain taxonomic problems in several taxa. One example is a brown frog of the genus and subgenus *Rana* endemic to the middle group. This frog is not a rare species and has been studied widely in these 60 years under the name of *R. okinavana* Boettger, 1895.

Boettger (1895a) described *R. okinavana* on the basis of three females (but see below) from “Liukiu-Inseln, angeblich von Okinawa in der mittleren Gruppe” (the Ryukyu Islands, allegedly from Okinawa in the middle group). Of these three specimens Boettger (1895b) listed, two are in the Senckenberg Museum, Frankfurt am Main (SMF) and the remaining one is said to be in the Bremen Museum (Stejneger, 1907). The catalogue number of the specimens in SMF, No. 1072, 1 shown in Stejneger (1907), seems to have been given shortly after Boettger’s (1895a) original description. Much later, Mertens (1967) designated the specimen with his catalogue number 1047, 3a in SMF to be the lectotype (SMF 5830), noting it to be a male.

Stejneger (1907: 102) examined the two specimens in SMF, translated the original German description and measurement table into English, and added short notes. Since then, nobody has examined the types in SMF except for Mertens (1967). Van Denburgh (1912) reported that he failed to collect *R. okinavana* from Okinawa (=Okinawajima I.), but that he could obtain 25 specimens from Ishigaki shima (=Ishigakijima I. in the southern group) that are referable to *R. okinavana*. This frog, however, has never been recorded from the southern Ryukyus by subsequent regional surveys (e.g., Okada, 1931). Boulenger (1920) stated that he had access only to the descriptions, which he summarized, and erroneously cited Boettger’s original remarks that the species is allied to “*R. labialis*”.

Meanwhile, the occurrence of a brown frog of the subgenus *Rana* (Dubois, 1992), superficially similar to *R. japonica* of the main islands of Japan, was known from Okinawajima I. of the middle group (Stejneger, 1907). In contrast to *R. okinavana* from the southern group, this brown frog has been reported by several authors from the middle group (e.g., Okada, 1931) and has experienced a complex taxonomic history (Shibata and Matsui, 1985). Inger (1947) combined the frogs from both the middle and southern Ryukyus and applied the name *R. okinavana* to them, although he examined only *R. okinavana* reported by Van Denburgh (1912) and did not study the brown frog of the middle group. Almost all subsequent researchers of the Ryukyus (e.g., Nakamura and Uéno, 1963; Maeda and Matsui, 1989, 1999) followed Inger’s (1947) view and used the name of *R. okinavana* for the brown frog from the middle group without any doubt.

As noted above, *R. okinavana* has not been reported from the southern group since Van Denburgh (1912), but another frog, *R. psaltes* Kuramoto, 1985, was found there much later (Kuramoto, 1973; Otsu, 1975). *Rana psaltes* is superficially similar to the brown frog of the middle Ryukyus in having moderate body size and brown dorsum. However, it is not a member of the subgenus *Rana*, but is the type species of *Nidirana* (Dubois, 1992; Maeda and Matsui, 1999).

In 1999, I had the chance to examine the lectotype and
a paratype of *R. okinavana* stored in SMF. My examination revealed that the types are completely different from the brown frog of the middle Ryukyus, now widely referred to "*R. okinavana"* (e.g., Nakamura and Uéno, 1963; Maeda and Matsu, 1989). Instead, they surely represent a member of the subgenus *Nidirana* (Dubois, 1992; Chou, 1999). The sole member of this subgenus known from the Ryukyus is *R. psaltes* Kuramoto, 1985, and I confirmed that it is conspecific with *R. okinavana*.

**MATERIALS AND METHODS**

I examined two type specimens of *R. okinavana*, SMF 5830 (lectotype) and 5831 (paratype). Both of these were formerly reported as 1072, 1 (Stejneger, 1907), but Mertens (1967) noted the lectotype as his 1047, 3. I found two small labels, one indicating 1072, 1a and another 1047, 3a, in the jar of SMF 5830. For comparisons, I examined the type series of *R. psaltes* from the southern Ryukyus [OMNH (Osaka Museum of Natural History) 10835=holotype; 8026–8030, 10836–10840=paratypes; all from Iriomotejima I. of the Yaeyama Islands] and specimens of the brown frog now widely called "*R. okinavana"* from the middle Ryukyus (KUHE=Graduate School of Human and Environmental Studies, Kyoto University 28141–28161 from Okinawajima I. of the Okinawa Islands).

Body measurements were taken mostly following Matsui (1984): Snout–vent length (SVL); head length (HL); head width (HW); snout length (SL); eye length (EL); tympanum diameter (TD); interaural distance (IND); interorbital distance (IOD); upper eyelid width (UEW); forelimb length (FL); hindlimb length (HLL); tibia length (TL); foot length (FL); inner metatarsal tubercle length (IMTL); first toe length (1TL). All measurements were made to the nearest 0.05 mm with dial calipers.

**RESULTS**

**Notes on types of *R. okinavana***

Both the two type specimens were in good condition (Fig. 1A, B, D, E, I), and the following original description by Boettger (1895b: 266; translated with slight modification by Matsu) will aid in defining this species: Canthus rostralis is blunt, but fairly distinct. Lores are nearly vertical and slightly concave. Snout is slightly longer than the upper eyelid, and is shorter than the distance of anterior corners of upper eyelids. Pinal spot is visible slightly posterior to the line connecting anterior borders of upper eyelids. Each of the vomerine teeth series bears four teeth.

The following additional information on the types of *R. okinavana* will aid in defining this species: Canthus rostralis is blunt, but fairly distinct. Lores are nearly vertical and slightly concave. Snout is slightly longer than the upper eyelid, and is shorter than the distance of anterior corners of upper eyelids. Pinal spot is visible slightly posterior to the line connecting anterior borders of upper eyelids. Each of the vomerine teeth series bears four teeth.

Both the two type specimens were in good condition (Fig. 1A, B, D, E, I), and the following original description by Boettger (1907: 102) proved to well illustrate them: "In general similar to *R. lateralis* Boulenger, but with shorter snout and more robust. Vomerine teeth in two rounded bundles beginning on a line with the posterior border of the choanae and separated from them as well as from each other by equal intervals. Head moderately large; snout short, anteriorly slightly pointed, and somewhat produced, as long as the diameter of the eye. Nostrils equidistant from tip of snout and eye. Canthus rostralis angular, loreal region slightly depressed longitudinally; interorbital space scarcely broader than the upper eyelid; tympanum very distinct, 3/4 the size of the eye. Fingers moderately long, first longer than second; toes 3/5 webbed and in addition with narrow dermal margins to the last phalanx; tips of digits truncate but without distinct disks; subarticular tubercles well developed; inner metatarsal tubercle oval, prominent, but less than half the length of the inner toe; no outer metatarsal tubercle. The adpressed hind leg reaches between anterior border of eye and nostril. Skin on back and underside rather smooth, on the sides with large flat warts; a narrow, high, strongly swollen dorso-lateral glandular fold; a second fold beginning beneath the eye and ending above the shoulder in two round or oval glandular aggregations. Upper side gray, frequently with a fine, somewhat lighter median dorsal line; a black wedge-shaped spot from nostril through eye extending over the temporal region; a blackish line bordering the upper lip and separated from the freno-temporal spot by a pure white band which ends on the glandular protuberances above the insertion of the arm. Tympanum brown. Dorso-lateral fold externally edged with black, the sides being often entirely blackish; posterior extremities with dark cross bands; posterior aspect of femur whitish yellow with black spots and marblings. Underside whitish yellow, spotted and dotted all over very densely with blackish brown, on the underside of the head being mostly uniform blackish gray".

Boettger (1895b: 267) noted that all the three syntypes are females, and Stejneger (1907) also noted the two specimens in SMF he examined as females. However, Mertens (1967) reported the lectotype to be a male, as noted above. Although I did not dissect the specimens, I reached a conclusion different from these previous authors, as shown below. The largest specimen in the measurement table of Boettger (1895b) assuredly represents the lectotype (SMF 5830: Fig. 1A, D), but it is not clear which of the remaining two specimens is the paratype (SMF 5831: Fig. 1B, E, I). From the body size, I tentatively assign the smallest one in Boettger’s (1895b) table to the paratype. The following is the comparison of measurements (in mm) made for the lectotype and paratype in this study (Table 1) and those given by Boettger (1895b), respectively: SVL=47.2 and 41.6 vs. 46 and 40, HL=17.7 and 15.2 vs. 17 and 16, HW=16.2 and 14.0 vs. 16 and 15, TD=4.1 and 3.8 vs. 4 and 3.5, FL=26.3 and 24.0 vs. 25 and 22.5, HLL=76.3 and 66.2 vs. 76 and 67, and TL=22.9 and 19.9 vs. 23.5 and 20.5. Thus, the two measurements agreed fairly well, in spite of the probably different methods used and possible shrinkage from over 100 years of preservation.

The first finger is longer than the fourth. Tips of fingers are swollen but lack the circummarginal groove. Tips of toes are also swollen, each with a circummarginal groove on second to fourth. Webbing formula is I2–2II2–3III2–3IV3–2V, with narrow dermal fringes to the last phalanx on all toes. A tarsal ridge is present, and a skin ridge fringes the fifth toe along its outer margin. In contrast to the original description, tibio-tarsal articulation reaches to the level of center of eye when hindlimb is carried forward along the body. Heels barely touch when hindlimbs are flexed perpendicular to the body axis.

The hindlimb is dorsally covered with several longitudi- nal tubercles, and those on tibia tend to form ridges. Most importantly, the paratype has a flat skin gland on the flank from the base of the forelimb to midway between axilla and groin (Fig. 1I; suprabrachial gland of Dubois, 1992), although the gland is much smaller and weaker in the lectotype. The paratype lacks distinct nuptial pads, but has small vocal openings inside of jaw comissures, though they are very difficult to locate. I could not find the openings in the lectotype. Thus, I judge the lectotype to be a female and...
the paralectotype to be a male. Dark bands on the hindlimb are narrowly edged with light color. The light-colored mid-dorsal stripe is nearly absent in the paralectotype.

**Comparisons with type series of *R. psaltes***

Almost all characteristics of the types of *R. okinavana* listed above agreed with those of *R. psaltes* examined, and there were only slight morphometric differences. Two female paratypes of *R. psaltes* were morphologically very similar to the lectotype of *R. okinavana*. The body size of the female *R. psaltes* (42.4–42.6 mm) was smaller than the size of *R. okinavana* (47.2 mm), but only a few of the morphometric
Table 1. Measurements (mean ± 1SD, in mm followed by ranges in parenthesis) of 14 characters in *Rana okinavana*, *R. psaltes*, and the brown frog from Okinawa. See Materials and Methods for museum and character abbreviations.

<table>
<thead>
<tr>
<th>Character</th>
<th>R. okinavana</th>
<th>R. psaltes</th>
<th>Brown frog from Okinawa</th>
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<tr>
<td>SVL</td>
<td>47.2 ± 1.6</td>
<td>41.0 ± 2.5</td>
<td>42.5 ± 1.8</td>
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<td>HL</td>
<td>17.7 ± 0.3</td>
<td>16.2 ± 0.3</td>
<td>14.0 ± 0.3</td>
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<tr>
<td>HW</td>
<td>16.2 ± 0.9</td>
<td>15.0 ± 0.6</td>
<td>14.3 ± 0.3</td>
</tr>
<tr>
<td>SL</td>
<td>7.3 ± 0.2</td>
<td>6.7 ± 0.3</td>
<td>6.6 ± 0.3</td>
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<tr>
<td>EL</td>
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<td>TD</td>
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<td>IND</td>
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<td>4.9 ± 0.3</td>
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<tr>
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<td>4.3 ± 0.3</td>
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<td>UEW</td>
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<td>FLL</td>
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<td>HLL</td>
<td>76.3 ± 4.6</td>
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<td>TL</td>
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<tr>
<td>FL</td>
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<td>IMTL</td>
<td>2.6 ± 0.1</td>
<td>2.2 ± 0.5</td>
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</table>

Comparisons with the brown frog from the middle Ryukyus

Two females of the brown frog now called "*R. okinavana*" from Okinawajima I. examined were morphologically fairly different from the lectotype of *R. okinavana*. Body size of the female brown frogs (47.5–49.9 mm) did not much differ from that of *R. okinavana* (47.2 mm). However, dimensions relative to SVL tended to differ markedly between the two species. Compared with *R. okinavana*, the brown frog had larger eye (13.1–14.0% vs. 12.5% in *R. okinavana*), forelimb (63.1–64.4% vs. 55.7%), hindlimb (190.8–192.8% vs. 161.7%), tibia (61.7–62.7% vs. 48.5%), and foot (55.7–57.1% vs. 49.4%), and smaller tympanum (6.8–8.3% vs. 8.7%), internarial (8.4–8.6% vs. 11.9%), interorbital (7.7–7.8% vs. 9.7%), and inner metatarsal tubercle (3.4–4.3% vs. 5.5%).

The males of the two species also differed. Nineteen male brown frogs were smaller (SVL=32.7–39.4 mm vs. 41.6 mm in *R. okinavana*) and had relatively larger eye (13.2–14.9% vs. 11.8%), forelimb (63.7–67.4% vs. 57.7%), hindlimb (182.0–200.5% vs. 159.1%), tibia (57.4–63.7% vs. 37.8%), and foot (55.4–60.6% vs. 49.3%), and smaller interorbital (7.7–9.2% vs. 11.8%) and interorbital (7.2–8.6% vs. 10.1%) than the *R. okinavana* paralectotype. Thus, in both sexes, the brown frog has larger eye, forelimb, hindlimb, values relative to SVL differed between the two species, although the small sample size prohibited statistical comparisons. Compared with *R. okinavana*, *R. psaltes* had larger forelimb (59.2–61.8% vs. 55.7% in *R. okinavana*), hindlimb (178.0–178.8% vs. 161.7%), tibia (54.2–54.7% vs. 48.5%), and foot (56.4–57.5% vs. 49.4%).

The male holotype (Fig. 1C, F, J) and eight male paratypes of *R. psaltes* were also very similar to the paralectotype of *R. okinavana*. The range of body size of male *R. psaltes* (39.5–42.8 mm) included the size of *R. okinavana* (41.6 mm), and they tended to differ only in a few dimensions relative to SVL; *R. psaltes* had larger eye (14.0–16.1% vs. 13.2% in *R. okinavana*), hindlimb (166.8–180.3% vs. 159.1%), forelimb (63.7–67.4% vs. 57.7%), and inner metatarsal tubercle (5.8–6.6% vs. 5.3%) than *R. okinavana*. These results indicate that *R. psaltes* and *R. okinavana* differ only in the relative size of the hindlimb and foot when both sexes are considered.

Although Kuramoto (1985) reported the absence of vocal sacs in *R. psaltes*, males of the type series proved to have vocal openings, as does the paralectotype of *R. okinavana*. Likewise, males of *R. psaltes* do not have distinct nuptial pads, but they do have small nuptial aspereities on the median surface of the first finger.
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tibia, and foot, and smaller internarial and interorbital, all relative to SVL, than _R. okinavana._

The brown frog (Fig. 1G, H, K) has a much more slender body, unlike the robust body of _R. okinavana_ and _R. psaltes_. The dorsum of the brown frog is scattered with small aspersities, and even in individuals with a nearly smooth dorsum, weak aspersities are found on the upper eyelid. These aspersities are never found in _R. okinavana_ and _R. psaltes_. In addition, the brown frog has a chevron ridge medial to the shoulder (Fig. 1G), like other frogs of the subgenus _Rana_, but this ridge is absent in _R. okinavana_ and _R. psaltes_. The brown frog also differs from _R. okinavana_ and _R. psaltes_ in the absence of distinct longitudinal rows of tubercles on the hindlimb. In the brown frog, the dorsolateral fold slightly diverges outward posterodorsal to the tympanum to form a weak supratympanic fold, but the dorsolateral fold is straight and does not flare out in _R. okinavana_ and _R. psaltes_. A marked difference is the absence in the brown frog of a suprabrachial gland, which characterizes _R. okinavana_ and _R. psaltes_.

The snout of the brown frog is more pointed and lower in height than in _R. okinavana_ and _R. psaltes_ (Fig. 1 J–K). The fourth finger is longer than the first in the brown frog, _Rana okinavana_. In the brown frog, the inner metacarpal tubercle is much less developed than in _R. okinavana_. The toe tip of the brown frog approaches forming a disc, but is smaller and less developed than in _R. okinavana_. In contrast, toe webbing is more developed in the brown frog than in _R. okinavana_ and _R. psaltes_, with the first to third toes fully webbed to the distal or second articulation. The brown frog has longer hindlimbs than _R. okinavana_ and _R. psaltes_, with the tibio-tarsal articulation reaching between eye and nostril or to the snout tip, or second articulation. The brown frog has longer hindlimbs than _R. okinavana_ and _R. psaltes_, with the tibio-tarsal articulation reaching between eye and nostril or to the snout tip, and even in individuals with a nearly smooth dorsum, the tympanum is masked black in the brown frog, unlike _R. okinavana_ and _R. psaltes_.

**DISCUSSION**

From the present examination of the types, it is evident that _R. okinavana_ is quite different from the brown frog now widely called under that name (e.g., Inger, 1947; Nakamura and Uéno, 1963: Maeda and Matsui, 1999), but is nearly identical with _R. psaltes_ (Kuramoto, 1985). Confusion of _R. okinavana_ with the brown frog from the middle Ryukyus seems to stem from the surveys of only the literature and not of the types, as well as from the lack of actual comparisons of specimens from both the middle and southern Ryukyus. _Rana okinavana_, the brown frog, and _R. psaltes_ are superficially similar in that they are moderate in size and have a brown dorsum. However, possession of a suprabrachial gland clearly separates _R. okinavana_ and _R. psaltes_ from the brown frog from the middle Ryukyus. Probably because all the previous authors (Stejneger, 1907; Van Denburgh, 1912; Bouleneger, 1920; Inger, 1947) failed to notice this structure, which was stated in the original description, although vaguely (“on the sides with large flat warts”: Boettiger, 1895a,b), and is actually present in the male _R. okinava_, the species was confused with the brown frog of the middle Ryukyus by the later authors.

The type locality of _R. okinavana_, “the Ryukyu Islands, so called Okinawa in the middle group” (Boettiger, 1895a, b), is most probably erroneous. Boettiger obtained specimens of _R. okinavana_ together with _Rana eiffingeri_ Boettiger 1895 [= _Chirixalus eiffingeri_ Boettiger (1895)] from a Japanese collector through Mr. B. Schmacker, then in Shanghai. Boettiger (1895a, b) reported the type locality of the former rhacophorid as Ohosima (= Amamioshima I.) or more probably Okinawa (= Okinawajima I.), the middle Ryukyus. However, as far as we know, _C. eiffingeri_ occurs only in the Yaeyama Islands (Ishigakijima I. and Iriomotejima I.) of the southern Ryukyus and Taiwan, and not in the middle Ryukyus (Maeda and Matsui, 1989).

Therefore, the type localities of the two frogs described by Boettiger (1895a, b) are both highly doubtful.

_Rana okinavana_, with a unique character of suprabrachial gland, is considered a member of the section Babina (Dubois, 1986: elevated to a genus distinct from _Rana_ by Frost et al., 2006), and more specifically, the subgenus Nidirana because of the presence of distinct dorsolateral fold (Chou, 1999). The only member of _Nidirana_ now known from Japan is _R. psaltes_. It was not long ago that the presence of a member of _Nidirana_ was ascertained in the Yaeyama Islands of the southern Ryukyus. Since the report of Van Denburgh (1912), no intensive research was made in the Yaeyama Islands, and no one secured specimens of _Rana_ with a moderate body size until the first half of the 1970s, when two authors independently reported a _Rana_ species from the Yaeyama Islands (Kuramoto, 1973; Otsu, 1975). Both of these authors identified the species as _R. adenopleura_ Bouleneger, 1909, originally described from Taiwan. Matsui and Utsunomiya (1973) reported marked differences in call characteristics between the populations of _R. adenopleura_ from the Yaeyama Islands and Taiwan, and suggested their independent taxonomic status. Finally, Kuramoto (1985) described the species from the Yaeyama Islands as _R. psaltes_.

It is very difficult to differentiate _R. psaltes_ from _R. okinavana_, as shown above, and it seems unlikely that more than one species occurs on small islands of the Yaeyama Islands (e.g., Ishigakijima I. and Iriomotejima I.) in the southern Ryukyus. Thus, it is most probable that _R. okinavana_ Boettiger, 1895 is identical with, and a subjective senior synonym of, _R. psaltes_ Kuramoto, 1985. Slight morphometric differences between the types of _R. okinavana_ and _R. psaltes_, especially in lengths related to the hindlimb, may include allometric and geographic variation. This may possibly be the case, if the syntypes of _R. okinavana_ were collected from Ishigakijima I. in contrast to those of _R. psaltes_ that were from Iriomotejima I., because some morphometric and genetic variation between the two islands has been reported for another ranid, _Rana (Odorrana) utsunomiyaorum_ (Matsui, 1994: Matsui et al., 2005). Because _R. psaltes_ is now known to occur also in Taiwan (Chou, 1994), the name for the Taiwanese population should be also changed.

As a result of this study, the brown frog now referred to “_R. okinavana_” from the middle Ryukyus proves to be distinct from true _R. okinavana_ and needs a formal description, which is now underway.
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