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Estimation of age structure and growth curve of *Aquarana catesbeiana* (Anura, Ranidae) in the Republic of Korea

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Abstract

The American bullfrog (*Aquarana catesbeiana*) is widely recognized as an invasive species with various harmful ecological impacts. Comprehensive population-specific information is required to develop effective management strategies to mitigate these impacts. However, studies examining the age structure and growth of this species, particularly within South Korean populations, are scarce. To address this gap, this study aimed to estimate the age structure and growth curve of *A. catesbeiana* populations in South Korea. A total of 49 individuals were collected from 10 sites in southwestern South Korea between 2019 and 2023. Age was estimated using skeletochronology, and lines of arrested growth (LAGs) were identified in bone cross-sections. Individuals were classified as males, females, or juveniles, with estimated age ranges of 1–5 years for males, 0–4 years for females, and 0–2 years for juveniles. No significant differences in age or snout–vent length were detected between sexes, whereas significant differences were observed between adults and juveniles. Because of the limited sample size, growth curves were estimated using male individuals only. The results revealed rapid growth up to 2 years of age, followed by deceleration in growth rate thereafter. Comparisons with native amphibians in South Korea indicated that the asymptotic size of *A. catesbeiana* is substantially larger, suggesting a high potential for ecological impacts on native amphibian communities. These findings provide population-specific information that can improve ecological risk assessment and support management efforts for *A. catesbeiana* under South Korean environmental conditions.

Key Words

ecological information, endangered species, invasive species, predation impact, skeletochronology

Introduction

The American bullfrog (*Aquarana* [*Lithobates*] *catesbeiana* Shaw, 1802), native to North America, is one of the most widely distributed invasive amphibian species worldwide (Lowe et al. 2000). Since its introduction, this species has established populations across multiple regions, including South America (Akmentins and Cardozo 2010; Both et al. 2011) and Europe (Grano and Cattaneo 2014). Such extensive range expansion has raised significant ecological concerns in invaded ecosystems (Luja and Rodríguez-Estrella 2010; Laufer et al. 2018). Additionally, *A. catesbeiana* causes habitat disturbances (Oh and Hong 2007) and is known to act as a potential vector for pathogens (Yap et al. 2018). One of the primary mechanisms underlying its ecosystem-level impacts is its broad and opportunistic predation behavior (Da Silva et al. 2009; Leivas et al. 2012; Jancowski and Orchard 2013; Liu et al. 2015). Larger amphibians are generally capable of consuming larger and more diverse prey,

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and *A. catesbeiana* is among the largest anuran species, with an average snout–vent length (SVL) exceeding 150 mm (Howard 1981). This large body size enables it to function as a generalist predator exploiting a wide range of prey, and its introduction has therefore been regarded as the introduction of a novel and influential predator (Park et al. 2018). Consequently, it has been designated as a regulated, ecosystem-disrupting invasive species in several countries, including South Korea (Ministry of Climate, Energy and Environment 2025a, 2025b).

Ecological traits of invasive species can shift in response to novel environments. In its native temperate range, *A. catesbeiana* exhibits reduced winter activity and may remain active beneath ice (Stinner et al. 1994), whereas populations introduced into subtropical environments maintain year-round activity with reduced reliance on hibernation (Medeiros et al. 2016). Comparable patterns have been documented in other invasive amphibians; for instance, *Rhinella marina* has adapted to colder climates and dispersed into montane regions (McCann et al. 2014; Mittan and Zamudio 2019). Such environmental variation commonly shapes amphibian life-history traits and morphology (Jang et al. 2011; Kang et al. 2017; Guo et al. 2019). Among these traits, growth rate and body size are key determinants of ecological impact (Wu et al. 2004; Wang et al. 2008). Because body size generally increases with age, analyses of age-dependent growth are fundamental to understanding population ecology (Halliday and Verrell 1988; Miaud et al. 1999). Consequently, spatial variation in body size may reflect differences in age structure among populations, particularly in widely distributed species such as *A. catesbeiana* that occupy diverse environmental conditions. Therefore, age-related data are essential for accurately interpreting variation in body size and growth patterns (Tessa et al. 2016). Moreover, comparing the age structure and growth patterns of invasive species with native species can help elucidate their ecological impacts within local ecosystems. However, studies examining the age structure and growth of *A. catesbeiana* remain limited and have been conducted in temperate regions, including North America, France, and China (Shirose et al. 1993; Xuan et al. 2010; Trauth and Welch 2014; Tessa et al. 2016).

In South Korea, *A. catesbeiana* was first introduced into natural environments in the early 1970s and is now widely distributed across the country (Kang et al. 2019). Although various studies have been conducted to support ongoing management efforts, ecological information on population characteristics remains limited (Groffen et al. 2019). As a result, management practices have often relied on data derived from populations in other regions. Because invasive species often exhibit region-specific ecological traits, growth and age estimates from other regions may not be directly applicable to South Korean populations, highlighting the need for region-specific assessments (Park et al. 2022). To address this gap, the present study estimated the age structure of South Korean populations of *A. catesbeiana* using skeletochronology and analyzed their growth curves. By comparing growth patterns, growth rates, and maximum body sizes with those of native frog species, this study provides baseline demographic data that contributes to understanding the ecological characteristics of this species under local environmental conditions.

Materials and methods

Sample collection

For the skeletochronology analysis, *A. catesbeiana* individuals of various sizes and sexes were collected from 10 sites between 2019 and 2023. Sampling was conducted in the southwestern region of South Korea, where populations are concentrated based on the distribution reported by Kang et al. (2019) and where extensive lowland plains facilitate efficient specimen collection (Fig. 1). Individuals were captured directly or collected from traps, including deceased specimens, during field surveys.

Upon collection, individuals were classified as male, female, or juvenile based on a combination of morphological characteristics (Werner et al. 2009). Males were identified by a yellow-colored jaw associated with vocal activity, tympana larger than the eyes, and the presence of nuptial pads on the forelimbs. Females were distinguished by a white jaw coloration contrasting with that of males, tympana smaller than the eyes, and the absence of nuptial pads. Individuals lacking these secondary sexual characteristics or exhibiting relatively small body size were classified as juveniles. Because the captured individuals included those that had died in traps, only SVL was measured. SVL was measured to the nearest 0.01 mm using digital calipers (150 mm, INSIZE, China).

After measurement, all individuals were euthanized by freezing in accordance with South Korea's invasive species management protocols and the guidelines of the Animal Experiment Ethics Committee (CNU IACUC-YB-2024-10). Subsequently, the longest toe (fourth) of the left hind limb was clipped using medical scissors and preserved in 70% ethanol for skeletochronological analysis.

Skeletochronology

Skeletochronology is based on the principle that seasonal climatic variations influence bone growth, resulting in the formation of growth layers. Counting the number of lines of arrested growth (LAGs) in bone cross-sections allows estimation of the age of an individual (Halliday and Verrell 1988; Francillon-Vieillot et al. 1990; Rahman et al. 2022; Park et al. 2026). The analytical procedure consisted of five main steps: (1) pre-treatment, (2) paraffin infiltration, (3) sectioning, (4) staining, and (5) observation. 1) Pre-treatment: Fixed samples were initially washed using a rotary shaker for a minimum of 12 h to remove the 70% ethanol used as a fixative. Subsequently,

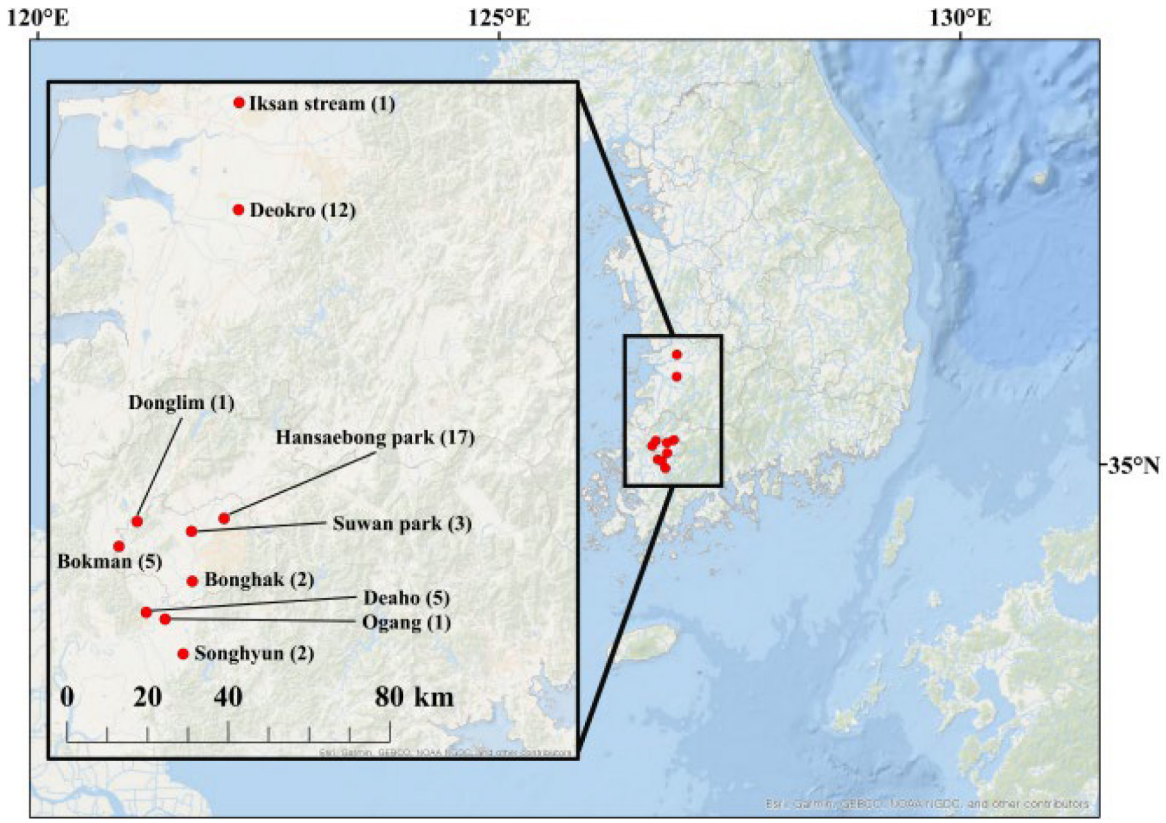

Figure 1. Capture sites of *Aquarana catesbeiana* used in this study. All individuals were collected between 2019 and 2023 during the active period from April to September. Red dots indicate the sampling sites, with the names of the locations shown on the side and the number of individuals captured at each site in parentheses.

samples were decalcified through immersion in 5% nitric acid for 2 h, followed by an additional washing step using a rotary shaker for more than 12 h. Following this, the samples were dehydrated through a graded ethanol series, progressing from 70% to 100%, and cleared using Histoclear. 2) Paraffin infiltration: Pre-treated samples were embedded in melted paraffin at a temperature of 60–70 °C and placed in a vacuum oven (VS-1202V5, Visionbionex Co., Ltd., Republic of Korea) for a minimum of 12 h to allow complete paraffin infiltration. 3) Sectioning: Following infiltration, samples were trimmed into paraffin blocks and transversely sectioned using a microtome (Leica RM2135) at a thickness of 10–14 µm. The sections were mounted sequentially onto glass slides and dried using a slide warmer for 24 h to ensure firm adhesion. 4) Staining: The sections were stained using the hematoxylin and eosin (H&E) staining method. Slides were immersed in Harris hematoxylin and Mayer's solutions for 30 min, followed by 15 dips in eosin solution. After staining, 3–4 drops of Permount were added, and the slides were covered with cover glass to create permanent preparations. 5) Observation: The prepared slides were examined using a light microscope (DM500, Leica, Germany) at 400× magnification. The smallest medullary cavity of the second phalanx, where the nutrient canal was visible, was selected for imaging. Four to nine images per sample were captured using an ICC50HD camera (LAS basic ver. 4.2, Leica, Germany).

The cross-section of the phalanx consists of a central marrow cavity that contains blood vessels and nerves and is surrounded by the periosteum. The periosteum consists of endosteal bone (EB) and periosteal bone (PB), which are separated by the Kastschenko line. LAGs are formed within PB and are counted to estimate age. In some species, the first LAG (LAG1) may undergo endosteal resorption and may not be visible in the PB (Hemelaar 1985). To mitigate this issue, the midshaft region of the second phalanx bone, where LAG1 was most effectively preserved, was selected for imaging. The second phalanx was selected based on its anatomical position between the cartilages of the first and third phalanges. The midshaft region was defined as the area where the marrow cavity was narrowest, the PB was widest, and the nutrient canal was present (Rozenblut and Ogielska 2005). Age determination was performed by counting the LAGs present in the PB (Park et al. 2026). Final age estimations were independently verified through consultation with two collaborating researchers to ensure accuracy.

Data analysis

All statistical analyses and graphical representations were performed using R software (ver. 4.3.0; R Core Team 2023). In the initial step, the normality of the data was assessed using the Shapiro–Wilk test with the

coin package (ver. 1.4-3; Hothorn et al. 2008), revealing that all data lacked normality ($p < 0.05$). Therefore, all analyses were conducted using nonparametric statistics. Comparisons among males, females, and juveniles were conducted using the Mann–Whitney *U* test, and the relationship between age and body size across all individuals was evaluated using Spearman's rank correlation analysis.

Growth curve analysis was performed using the von Bertalanffy (1938) growth model:

$$\mathbf{S_t} = \mathbf{S_m} - (\mathbf{S_m} - \mathbf{S_0}) * \mathbf{e}^{-\mathbf{k}(\mathbf{t}-\mathbf{t_0})}$$

where S_t represents the mean snout–vent length (SVL) of individuals at age t. S_0 represents the SVL at metamorphosis, t denotes individual age, t_0 is the age at metamorphosis, S_m denotes the asymptotic size (SVL), and *k* is the growth coefficient.

The age of all individuals was estimated using skeletochronology, and the mean SVL for each given age was calculated and assigned as S_t. The SVL at metamorphosis (S_0) was set to 45 mm, based on measurement of metamorphosed individuals captured in the wild in April 2025 (Table 1) and with reference to values reported for other populations (52 mm; Collins 1979). The asymptotic size (S_m) and growth coefficient (*k*) were estimated by fitting the von Bertalanffy growth model using the nlsLM function from the minpack.lm package (ver. 1.2-4; Elzhov et al. 2023). The age at metamorphosis (t_0) was defined based on previous studies (Howard 1981; Xuan et al. 2010), which reported values ranging from 0.5 to 3 years depending on environmental conditions and geographic region. Accordingly, the growth model was fitted using fixed t_0 values of 0.5, 1, 2, and 3 years, and the adequacy of these models was compared to identify the most appropriate t_0 value. The corresponding estimates of S_m and *k* were used as the final parameters for the growth model. Model adequacy was assessed using the pseudo-R^2 value ($R^2 > 0.5$ indicating an acceptable fit). To assess the reliability of the estimated parameters, 95% confidence intervals were calculated based on the standard errors obtained from the nonlinear model fitting. The final estimated growth curve was visualized using the ggplot2 package (ver. 3.5.1; Wickham et al. 2016).

Additionally, to assess differences in estimated age structure and asymptotic body size between *A. catesbeiana* and native amphibians, a targeted literature review was conducted. Searches were performed using two academic databases: Google Scholar (https://scholar.google.co.kr) and RISS (https://www.riss.kr). Because the aim was to compare the results with native amphibian species in South Korea, searches were performed only in English and Korean. Search keywords included the scientific names of amphibian species occurring in South Korea, along with the keywords "age structure" and "skeletochronology." To ensure relevance, only studies based on populations from South Korea were retained for analysis.

Table 1. Mean SVL and range by age in *Aquarana catesbeiana*. Values are presented as the mean ± standard deviation (SD), with ranges expressed as minimum and maximum.

Sex and age	*N*	Mean ± SD (mm)	Range (min–max, mm)
Metamorphosed individuals	**3**	**45.0 ± 5.6**	**39.9–51.0**
Juvenile			
0	7	90.4 ± 20.2	56.8–117.3
1	4	94.8 ± 4.3	91.1–99.0
2	2	87.2 ± 20.5	72.7–101.7
Total	**13**	**91.3 ± 15.8**	**56.8–117.3**
Male			
1	9	109.8 ± 10.6	88.8–127.5
2	10	117.6 ± 14.5	102.8–144.6
3	2	126.3 ± 14.6	116.0–136.6
4	2	170.1 ± 39.2	142.4–197.8
5	2	139.6 ± 3.2	137.3–141.8
Total	**25**	**121.5 ± 21.7**	**88.8–197.8**
Female			
0	1	104.9	*
1	1	104.4	*
2	2	124.9 ± 2.8	123.0–126.9
3	1	142.6	*
4	1	136.5	*
Total	**6**	**123.1 ± 15.8**	**104.4–142.6**

Result

Skeletochronology

A total of 49 individuals were collected, and sex was determined based on external morphological characteristics prior to skeletochronological analysis. Five individuals (three males and two females) were excluded from the analysis due to bone fragmentation during the sectioning process. Consequently, age estimation was performed on 44 individuals, of which 25 were classified as males, six as females, and 13 as juveniles (Table 1). Distinct LAGs were observed in all 25 males (Fig. 2A–C). Among females, LAGs were visible in five of the six individuals. Among juveniles, seven individuals showed no visible LAGs, whereas six exhibited distinct LAGs (Fig. 2D). Individuals with no visible LAGs were classified as age 0. Most LAGs appeared thin and well-defined; however, thicker LAGs were observed in 12 individuals (27.3%). Additionally, double lines or false lines were detected in six individuals (13.6%), and signs of endosteal resorption were observed in six individuals (13.5%).

Age structure estimation

The mean age and SVL of the collected individuals were analyzed. Males exhibited a mean SVL of 121.5 ± 4.3 mm (range: 88.8–197.8 mm, $N = 25$) and a mean age of 2.1 ± 1.2 years (range: 1–5, $N = 25$; Table 1). Females had a mean SVL of 123.0 ± 6.5 mm (range: 104.4–142.6 mm, $N = 6$) and a mean age of 2.0 ± 1.4 years

(range: 0–4, N = 6; Table 1). Juveniles exhibited a mean SVL of 91.3 ± 15.8 mm (range: 56.8–117.3 mm, N = 13) and a mean age of 0.6 ± 0.8 years (range: 0–2, N = 13; Table 1). Comparisons of SVL among the three groups revealed no significant difference between males and females (U = –0.15, p = 0.88). In contrast, significant differences were found between females and juveniles (U = 3.07, p < 0.05) and between males and juveniles (U = 4.11, p < 0.05). Similarly, significant age-related differences were observed between females and juveniles (U = 2.17, p < 0.05) and between males and juveniles (U = 3.73, p < 0.05), whereas no significant difference was observed between males and females (U = 0.02, p = 0.98). Spearman correlation analysis showed a significant positive correlation between SVL and age (N = 44, rho = 0.670, p < 0.05), indicating that older individuals tended to have larger SVL.

Growth curve and comparison with native species

Because the number of females was insufficient and juveniles were identified only within the 0–2-year age range, growth curves were estimated using 25 male individuals aged 1–5 years in the present study. In the growth model, when t_0 = 0.5, the estimated asymptotic size (S_m) was 143.7 mm (p = 0.002), and the growth coefficient (k) was 1.5 (p = 0.2), with a strong model fit (pseudo-R^2 = 0.879). However, model fit decreased as $t0$ increased. When t_0 = 1, the estimated values were S_m = 153 mm (p = 0.029), k = 1 (p = 0.5), and pseudo-R^2 = 0.559. At t_0 values of 2 and 3, the model failed to converge, and reliable estimates for S_m and k could not be obtained. Therefore, growth curve analysis was based on the model with t_0 = 0.5, which exhibited the best fit. The curve indicates rapid growth up to 2 years of age, followed by a gradual slowdown, approaching an asymptote at approximately 3.8 years to S_m (Fig. 3). A literature review on the age structure of anuran species in South Korea identified 11 studies encompassing 11 frog species. Because growth curves in the present study were derived from male individuals, and several previous studies focused exclusively on males, only male data were extracted and summarized (Table 2). Most species exhibited an age distribution ranging from 2 to 7 years, with a minimum recorded age of 1 year and a maximum of 9 years. The asymptotic sizes among these species ranged from 40.8 to 83.9 mm.

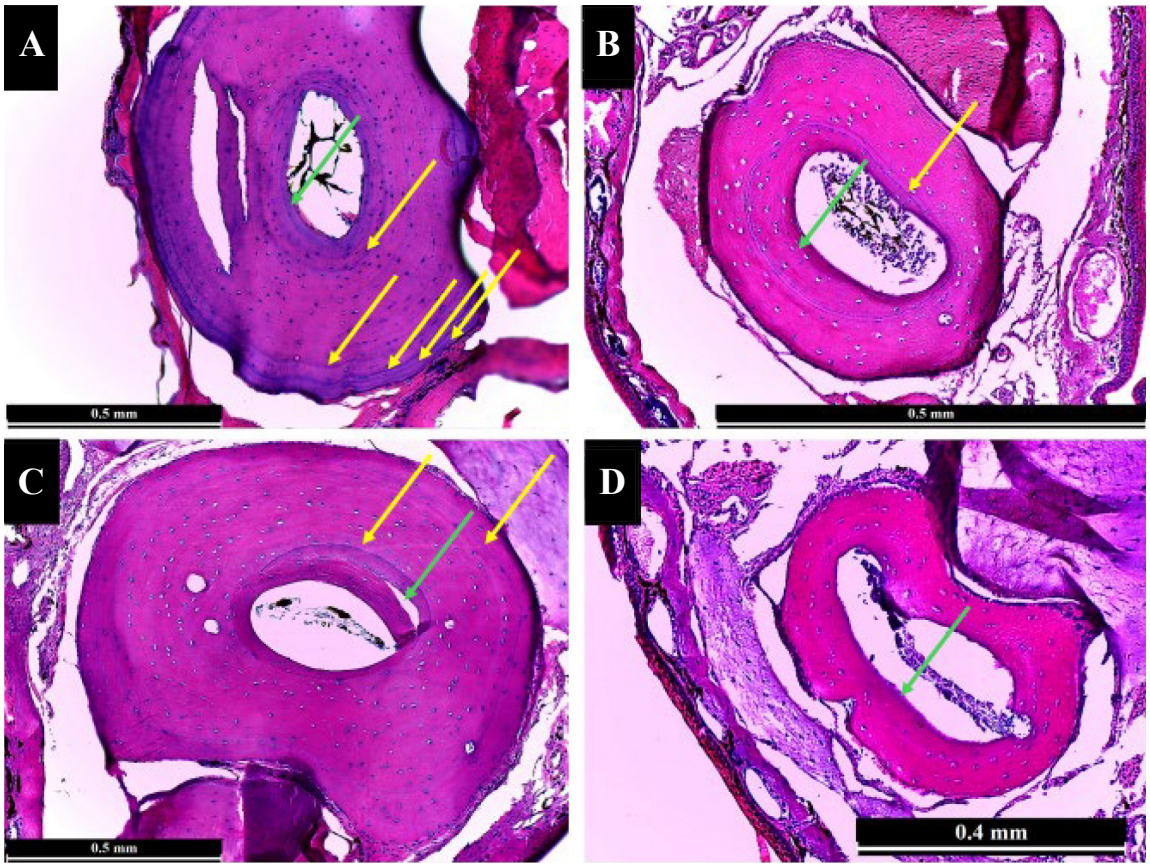

Figure 2. Cross-section of the toe bone of *Aquarana catesbeiana*. The yellow arrows indicate the lines of arrested growth (LAGs), and the green arrow indicates the Keschenko line (KL), which marks the boundary between the periosteal bone (PB) and endosteal bone (EB) zones. The empty central area is the marrow cavity. (**A**) HS09 (male): Estimated to be 5 years old based on the LAGs, with three LAGs overlapping at the end of the PB zone. (**B**) DR02 (male): The two LAGs are very close and were judged to be double lines; the individual was estimated to be 1 year old. (**C**) SW01 (male): Based on the position of the KL (green arrow), the first LAG was judged to have undergone endosteal resorption, and the individual was estimated to be 2 years old. (**D**) SH05 (juvenile): The KL (green arrow) is visible, but no LAGs were observed, resulting in an estimated age of 0 years.

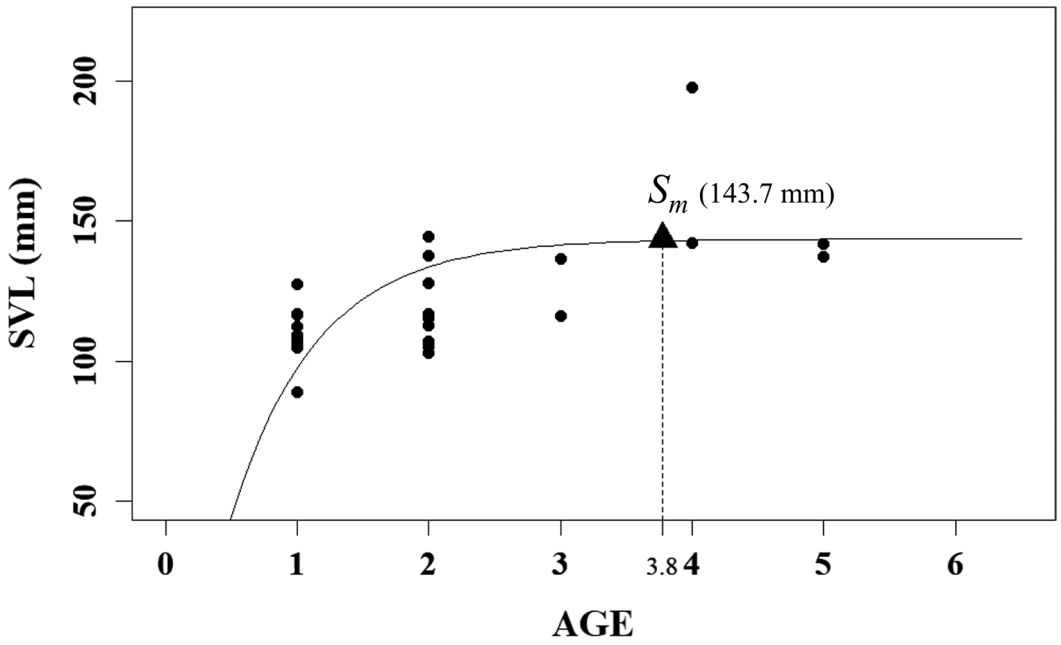

Figure 3. Age distribution and estimated growth curve of male *Aquarana catesbeiana* in South Korea. Each black dot represents the SVL of an individual at given age, and the solid line indicates the estimated von Bertalanffy growth curve. The curve shows rapid growth up to age 2. The black triangle represents the asymptotic size (S_m = 143.7 mm), which is reached at approximately 3.8 years of age.

Table 2. Age range and asymptotic size of male individuals within the order *Anura*, inhabiting South Korea. Multiple references for a species and studies covering two regions are classified separately. An asterisk (*) next to a species name indicates an endangered species in South Korea, and a dash (-) in the asymptotic size column indicates that no data are available.

No.	species	Age range (year; min–max)	Asymptotic size (mm)	References
1	*Bombina orientalis*	1–6	-	Doh 2021
2	*Bufo gargarizans*	1–6	83.4 90.1	Park et al. 2026
3	*B. stejnegeri*	1–5	-	Lee and Park 2009
4	*Dryophytes japonica*	2–5	-	Ham 2014
5	* *D. suweonensis*	2–5	-	Ham 2014
6	* *Kaloula borealis*	2–8	46.4	Ko et al. 2011
		2–8	43.1	Rahman et al. 2022
7	*Rana uenoi*	3–9	-	Ko 2012
8	*R. huanrenensis*	3–8	56.3	Seo 2011
9	*Pelophylax nigromaculatus*	2–8	60.3	Cheong et al. 2013
10	* *P. chosenicus*	2–5	34.7	Cheong et al. 2007
		3–7	40.8	
11	*Glandirana rugosa*	3–6	41.0	Lee et al. 2011
Aquarana catesbeiana		1–5	145.5	This study

Discussion

In this study, the age structure of *A. catesbeiana* inhabiting South Korea was estimated using skeletochronology. No significant differences in SVL were observed between sexes, whereas SVL differed significantly between adults and juveniles. Males were readily distinguished by their yellow throat coloration and presence of nuptial pads; however, females and juveniles lacked clear external differences, making classification dependent on SVL measurements (Werner et al. 2009; Urbina et al. 2020). In South Korea, individuals with SVLs between 80 and 120 mm are generally regarded as juveniles (Jancowski and Orchard 2013; Park et al. 2018), and the samples fell within this range. Despite this classification, several individuals showed differences among SVL, sex classification, and estimated age. One individual classified as female exhibited no visible LAGs and was assigned an age of 0, whereas two individuals classified as juveniles were estimated to be 2 years old. These findings suggest that age, growth, and sexual maturity are not correlated and may vary in response to local environmental conditions. LAGs form when physiological or environmental conditions slow skeletal growth, resulting in calcium deposition that appears as visible lines (Phadmacanty et al. 2025; Lyap-

kov 2025). Although LAGs are typically associated with winter hibernation, they may also form during periods of aestivation (Sinsch et al. 2007). Phadmacanty et al. (2025) reported that LAG formation can be influenced by reduced foraging activity during the dry season as well as by genetic factors. Therefore, multiple biological and ecological factors should be considered when interpreting the presence or absence of LAGs. As an invasive species that has expanded across diverse environments, *A. catesbeiana* may exhibit considerable variation in growth and maturation rates depending on local climate and resource availability (Allen et al. 2017). Although LAGs typically form during hibernation, some populations of *A. catesbeiana* remain active throughout the winter (Stinner et al. 1994), potentially reducing or preventing LAG deposition. Consequently, individuals that have reached a body size indicative of sexual maturity may still exhibit few or no visible LAGs. Furthermore, LAGs may be partially or entirely obscured by endosteal resorption (Sinsch 2015). Given these constraints, age estimates derived from skeletochronology should be interpreted with caution. Additional studies are needed to clarify the relationships among external morphology, growth dynamics, and LAG formation in South Korean populations of *A. catesbeiana*.

Because of the small sample size and challenges in accurately classifying juveniles and females, the growth curve was estimated using only male individuals. Furthermore, the data were collected from multiple locations across southwestern Korea rather than from a single, ecologically uniform population. This geographic variability introduces the possibility that environmental heterogeneity may influence growth patterns, a limitation that should be considered when interpreting the results. Moreover, age at metamorphosis in *A. catesbeiana* is known to be highly variable and strongly influenced by various factors (Howard 1981; Xuan et al. 2010). However, this relationship has not been quantitatively characterized for populations in South Korea. Previous studies from other regions indicate that larval duration and age at metamorphosis can vary substantially across climatic and ecological contexts. Consequently, although the selection of $t_0 = 0.5$ was based on model performance, this value may not fully reflect the ecological conditions of the study area and should be interpreted with caution. Despite these constraints, the von Bertalanffy model fitted to male individuals showed a strong model fit (pseudo-$R^2 = 0.879$) and a robust relationship between age and body size. Rapid growth during the first 2 years was consistent with previous studies (Tessa et al. 2016), and the asymptotic size estimated for males in this study (143.7 mm) was comparable to values reported for North American and Chinese populations (e.g., 148 mm, Shirose et al. 1993; 142.62 mm, Xuan et al. 2010). These results suggest that male *A. catesbeiana* in South Korea may follow growth curves similar to those observed in native and other introduced ranges, supporting concerns regarding their potential ecological impact.

These growth patterns were further compared with those of native male amphibian species in South Korea. Most amphibian species in South Korea exhibit rapid growth until approximately 2 years of age, followed by a gradual deceleration from around age three onward (Cheong et al. 2007; Lee et al. 2009; Seo 2011; Ko et al. 2011; Cheong et al. 2013; Rahman et al. 2022; Park et al. 2026). However, the asymptotic size of *A. catesbeiana* (143.7 mm) is approximately three times larger than that of the Korean endemic species *Pelophylax chosenicus* (34.7 mm; Cheong et al. 2007). Consequently, although the overall growth curves are similar to those of native amphibians, the substantially larger body size attained during the approximately 2-year maturation period indicates that *A. catesbeiana* grows considerably faster. Amphibians feed on organisms smaller than themselves, and the larger-bodied *A. catesbeiana* is known to consume a considerable amount of food (Wu et al. 2004; Wang et al. 2008). Even in South Korea, *A. catesbeiana* has been reported to prey on *Bufo gargarizans* and *P. nigromaculatus* (Park et al. 2018). However, the impacts of *A. catesbeiana* invasion are not limited to direct predation. Native amphibians that are unfamiliar with invasive predators may fail to exhibit effective antipredator behaviors, thereby increasing their vulnerability and amplifying ecological impacts (Kiesecker and Blaustein 1997). Additionally, *A. catesbeiana* can contribute to population declines through broader ecological disturbances (Doubledee et al. 2003) and may act as a vector for *Batrachochytrium dendrobatidis*, a pathogen that is often lethal to amphibians (Miaud et al. 2016; Yap et al. 2018). Overall, these findings indicate that *A. catesbeiana* poses a significant threat to native amphibian communities and ecosystem stability.

Conclusion

This study estimated the age structure and growth characteristics of *A. catesbeiana* in South Korea using skeletochronology. The formation of LAGs was confirmed in the South Korean population, with age distributions of 1–5 years in males, 0–4 years in females, and 0–2 years in juveniles. Because of limited data availability, growth curves were analyzed for males only, revealing rapid growth up to 2 years of age, followed by a slowdown from age three onward. Although this growth pattern was similar to that observed in native male amphibians in South Korea, the asymptotic size of *A. catesbeiana* was more than triple that of the native species. These results suggest that the large body size of *A. catesbeiana* may contribute to its ecological impact on native amphibian communities. By providing age structure and growth data based on South Korean populations, this study offers baseline demographic information that improves understanding of the species' ecological characteristics under local environmental conditions.

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Competing Interests

The authors have declared that no competing interests exist.

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