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Research Article

Understanding The Current Knowledge and Potential Research of Indonesia's Only Protected Amphibian: The Bleeding Toad (*Leptophryne cruentata*)

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ABSTRACT
Globally, amphibian populations are facing a substantial decline attributed to environmental degradation and lack of public attention. Indonesia, which one of countries with the high number of amphibian species in the world, paradoxically holds the record for the highest number of data-deficient amphibians. Indonesia currently has only one protected species, the bleeding toad (*Leptophryne cruentata*) also categorized as Critically Endangered. Considering this, our study undertakes a comprehensive review of bleeding toad research, highlighting research gaps and identifying potential topics for future investigations. In this study, we used an electronic database to acquire relevant studies aligned with our research objectives. The literature collection process involved the utilisation of the Publish or Perish (PoP) and manual internet searches. Our documentation reveals limited literature on bleeding toads, comprising only 20 reviews, with a notable prevalence of grey literature. This underscores the critical endangerment of bleeding toads, coupled with their neglect in research endeavours. Furthermore, our examination presents limited information on crucial aspects, such as taxonomy, morphology, geographical distribution, habitat characteristics, encounter records, behaviour, protection status, threats, and bioprospecting. The research gap is exceptionally high, with only two out of the 11 research topics attaining sufficient research status. Our findings underscore the urgent need for further research in this area. We identified at least 18 potential research areas that were essential for completing the baseline data. These findings serve as a valuable resource for researchers and policymakers seeking to address the critical endangerment of bleeding toads and to formulate effective conservation strategies.

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INTRODUCTION

Biodiversity loss has been ranked the third most threatening global risk in the last decade, following climate change and extreme weather (World Economic Forum 2022). The Anthropocene is a contributing factor to the high loss of biodiversity (Meng et al. 2021), which may indicate an ongoing mass extinction process attributable to factors such as habitat loss, overharvesting, climate change, fragmentation, forest and land fires, and invasive species (Singh et al. 2021). Amphibians, as a taxonomic group, have experienced significant population decline over the last decade for various reasons, signalling a biodiversity crisis (Luedtke et al. 2023). Currently, amphibians are confronted with an unprecedented extinction crisis (Catenazzi 2015). According to Luedtke et al. (2023), from a preliminary assessment in 2023, the global condition of amphibians is progressively worsening, with 40.7 % (2873 species) currently categorised as globally threatened under the IUCN Red List classifications of Critically Endangered (CR), Endangered (EN), and Vulnerable (VU). This represents an increase of 37.9 % (2681 species) in 1980 and 39.4 % (2788 species) in 2004. Luedtke et al. (2023) also mentioned the biggest factors contributing to amphibian extinction include agriculture (impacting 77 % of species), timber and plant harvesting (53 %), infrastructure development (40 %), climate change effects (29 %), and disease (29 %). Moreover, a lack of attention to amphibians has resulted in the significantly low popularity of amphibian conservation. Data from Evolutionarily Distinct and Globally Endangered (EDGE) Species indicates that amphibians and corals are the taxa receiving the least conservation attention, further emphasizing the urgency of addressing their conservation needs (Zoological Society of London 2020).

Indonesia, a globally significant Southeast Asian country for biodiversity, unfortunately possesses the highest number of species at serious risk of extinction (Duckworth et al. 2012; ASEAN Centre for Biodiversity & IUCN SSC Asian Species Action Partnership 2020). Indonesia ranks among the top ten countries globally, with the highest number of amphibian species, boasting a total of 418 species, including 224 endemic and 194 non-endemic species (Re:wild, Synchronicity Earth, and IUCN SSC Amphibian Specialist Group 2023). Habitat degradation and fragmentation are the primary factors that contribute to species extinction in Indonesia (Maskun et al. 2021). In addition to habitat destruction, Indonesia faces challenges in amphibian conservation due to low attention and research directed towards less charismatic amphibian species. This lack of focus contributes to the limited amount of research and funding dedicated to amphibian conservation efforts (Kusrini 2007a). Indonesia has the distinction of being the country with the highest number of amphibians, categorised as having a data-deficient status (Re:wild, Synchronicity Earth, and IUCN SSC Amphibian Specialist Group 2023). The low level of amphibian research is also exacerbated by numerous constraints; for example, the science community (bureaucratic processes at all project stages, including planning, visa procedures, fieldwork permits, scientific exchange, and project management issues, coupled with government budget cuts for basic research and limited access to international literature for Indonesian researchers) significantly impedes the internationalisation of biodiversity-related science (von Rintelen et al. 2017).

According to the ASEAN Centre for Biodiversity and IUCN SSC Asian Species Action Partnership (2020), Indonesia currently has three amphibian species on the IUCN Red List with the Critically Endangered (CR) category. There are bancet tompotika (*Occidozyga tompotika*), jacobson's bubble nest frog (*Philautus jacobsoni*) and bleeding toad (*Leptophryne cruentata*). The bleeding toad is a species that warrants special attention, as it is the sole amphibian species protected by Indonesian law under Permen-LHK P.106/2018. This species faces a high threat status owing to its limited distribution on Java Island, declining population, and habitat destruction. Despite these challenges, attention given to this species is notably low. Consequently, we conducted a comprehensive review and analysis of the available data on the conservation status of the bleeding toad, aiming to (i) Analyse the extent of the research conducted on the bleeding toad. (ii) Present a comprehensive overview derived from existing literature on taxonomy, morphology, geographical distribution, habitat characteristics, encounter records, behavior, protection status, threats, and bioprospecting of the bleeding toad. (iii) Identify research gaps and potential topics for future investigations on bleeding toads. Therefore, our study represents a comprehensive synopsis of the largest online databases from which we highlight the extent of research on bleeding toads.

MATERIALS AND METHODS

Before initiating this study, we established the specific inclusion criteria (Table 1). These criteria play a pivotal role in the review process and serve as a precise framework for the selection of acquired publications. Furthermore, they contribute to the credibility of the review by allowing other researchers to employ the same protocol to replicate the study, thereby facilitating cross-validation and verification (Xiao & Watson 2019).

Table 1. Inclusion criteria for studies included in systematic review.

No.	Criteria	Rationale
1	Publications were gathered through the utilization of the *Publish or Perish* application and manual internet searches. The collected data encompassed publications indexed by Scopus and Google Scholar, as well as grey literature.	Ensure the quality and quantity of research. Grey literature included because many research is unpublished but valuable
2	Publication are written in English or Indonesian	Publications are not only written in English, but many publications are in Indonesian but have high value.
3	Publication titles and authors are complete and searchable	Publications must be traceable so that they can be analysed in more depth

In this study, we used an electronic database to acquire relevant studies aligned with our research objectives. The literature collection process involved the utilisation of the Publish or Perish (PoP) application (Harzing 2011) and manual Internet searches. Our primary research databases were Google Scholar and Scopus. The search procedure was carried out in the "title words" section, using the terms “bleeding toad," "kodok merah," and "*Leptophryne cruentata*." Subsequently, the search results were saved as *.csv* files, and later transformed into *.xls* format for further analysis. The data cleaning process was systematically executed to ensure the completeness of publication metadata and eliminate any instances of duplicated data, which may have originated from searches conducted on Google Scholar, Scopus, and through manual internet searches (Figure 1). The data search spanned from the earliest available year to 1 September 2023.

A total of 25 records were initially identified, but only 20 met the inclusion criteria for subsequent analyses (Figure 1). The selected literature for analysis encompassed various categories of publications, including those published in scientific journals, theses, unpublished reports, seminar proceedings, books, and other types of publications such as multimedia, posters, and magazines. Additionally, data collected through the *Publish or Perish* (PoP) application were saved in *.ris* format for subsequent analyses using *VOSviewer*.

VOSviewer is a software tool designed for generating network-based maps and visualising and exploring these maps. This application is primarily intended for analysing bibliometric networks (van Eck & Waltman 2022). In this study, we used *VOSviewer* to construct collaboration maps based on co-authorship and co-occurrence analyses, utilising the entire dataset. The analysis of research gaps and potential topics for future research was conducted using the data approach for the analysis of frog survival and population viability using Vortex by Davis et al. (2019) and The Amphibian Conservation Action Plan (Gascon et al. 2007; IUCN SSC Amphibian Specialist Group 2022).

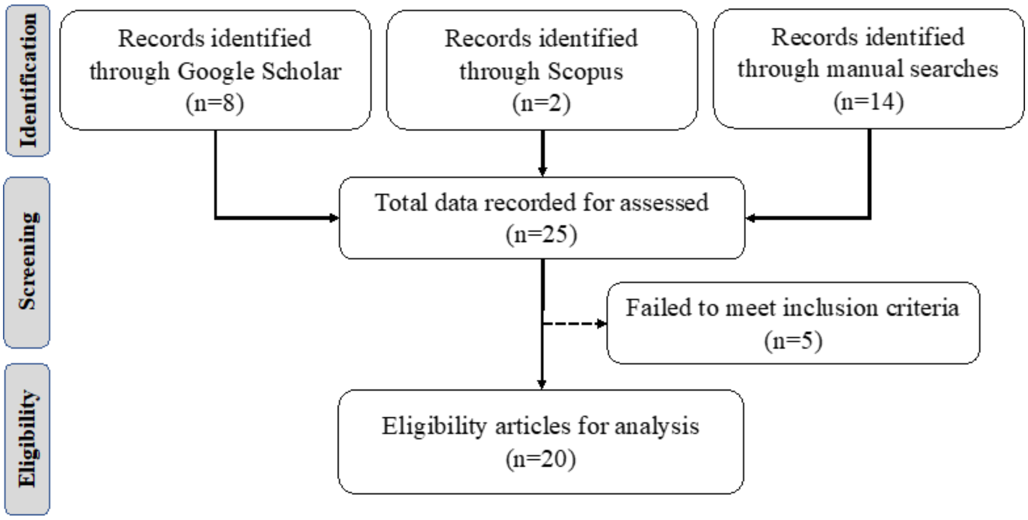


Figure 1. Data cleaning process.

RESULTS AND DISCUSSION

The current state of research conducted on the bleeding toad

As of 1 September 2023, 20 studies had been conducted on this amphibian species. However, despite the bleeding toad status as the only protected amphibian species in Indonesia, the quantity of research dedicated to this species remains relatively limited compared to other species. Literature searches on this species are still notably constrained, with only 25 % of the total literature having citations on Google Scholar and Scopus, whereas 75 % are uncited literature (manual searches) (Figure 2a). Literature that is not cited in Google Scholar and Scopus is typically referred to as grey literature. Grey literature encompasses output texts that are not formally commercially published by academic publishers. This includes, but is not limited to, webpages, patents, preprints, white papers, social media content, unpublished reports, theses, conference proceedings, and government documents (Schöpfel 2006). While grey literature may have shortcomings and often does not undergo the peer review process, its significance becomes evident when the availability of cited literature is limited (Kousha et al. 2022). The large amount of grey literature proves that this species is neglected. There are 40 % of bleeding toad literature published in journals, 40 % in identification manuals, and 20 % in magazines and unpublished theses (Figure 2b). Of the 40 % of the literature published in journals, around 15 % are not cited on Google Scholar or Scopus.

Research on the bleeding toad has shown an increasing trend, particularly following its designation as the only protected amphibian in Indonesia in 2018 (Figure 2d). The trajectory of research development on this species dates to 1838, when Tschudi initially described the species found in Cibodas, Cianjur, and West Java. Then in 1998, Iskandar (1998) stated that this species was no longer found in Cibodas. In 2005, Kusrini et al. (2005) embarked on a search and successfully found individual of bleeding toads. Due to the precariousness of population of this species Kusrini (2006) proposed that this species should be protected. From 2006 to 2023, bleeding toad research gained momentum, with a total of seven studies conducted, notably led by research leader Mirza D. Kusrini (Kusrini 2007b; Yazid 2007; Oktalina 2010; Artika et al. 2015a; Artika et al. 2015b; Setiawan et al. 2021; Hasan 2022). Thus, bleeding toad researchers are predominantly Indonesian, comprising 75 %, with the remaining 25 % being foreign researchers (Figure 2c).

Only eight studies were cited by Scopus and Google Scholar and subsequently used as sources for *VOSviewer* mapping. The network visualization map of *Leptophryne cruentata*, as depicted in Figure 3a, highlights that the most influential and widely cited research pertains to the study of skin secretion (Artika et al. 2015a, 2015b), This is attributed to the fact that these two citations were published in reputable journals indexed by Scopus. The limited publication of bleeding toad research in reputable journals has resulted in unconnected network visualisation. Among the 20 available literature, bleeding toad research has covered seven distinct topics, including distribution, habitat, behavior, population, bioprospecting, taxonomy and morphology, and disease threats (Figure 3b). Distribution was the most discussed topic in 11 studies, followed by habitat, which was covered in nine studies. Behaviour was discussed in six studies, while the other topics had ≤5 occurrences, indicating a relatively low level of discussion on these subjects. Although the topic of distribution is the most discussed, the records of discovery locations tend to remain in the same locations. Consequently, some topics lacked sufficient data coverage. The most influential and widely cited author is IM. Artika and Mirza D. Kusrini became a frequent author in every bleeding toad publication (Figure 3c).

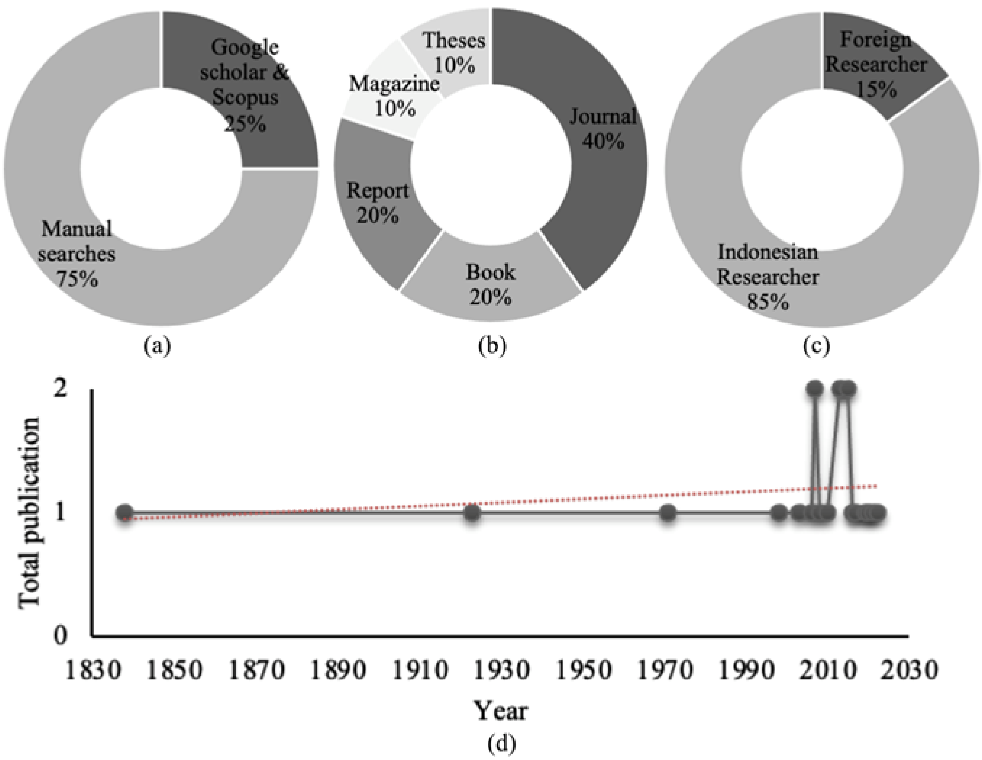
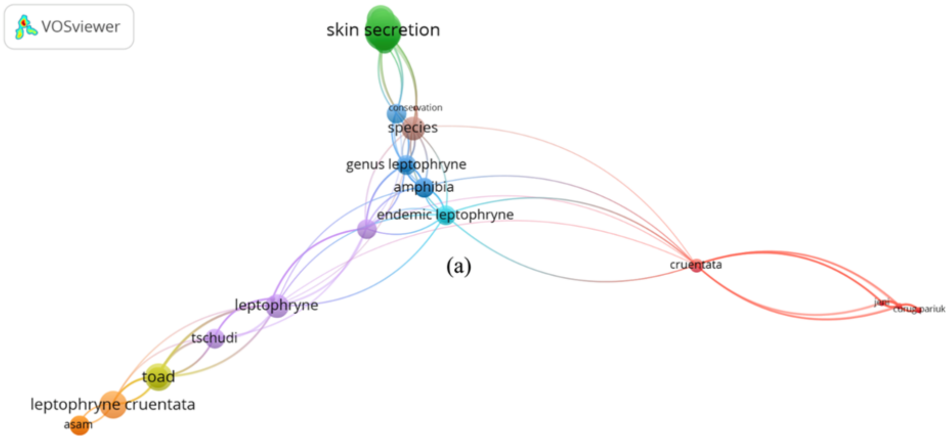


Figure 2. Basic findings of bleeding toad research. (a) literature search; (b) literature type; (c) researcher; (d) research trend.



(a)

Research topics	Number of studies that discuss
Distribution	11
Habitat	9
Behavior	6
Population	5
Bioprospecting	2
Taxonomy & morphology	2
Disease threat	1

(b)

Authors	Cites
IM Artika, S Pinontoan, MD Kusrini	5
IM Artika, S Pinontoan, MD Kusrini	3
H Kurniati	3
DT Iskandar, Mumpuni	2
MD Kusrini, M Yazid	2
GM Hasan, MD Kusrini	0
S Oktalina, MD Kusrini	0

(c)

Figure 3. (a) Research topics, (b) network-visualization map research, and (c) influential researcher.

Existing research information on bleeding toad

Taxonomy and morphology

The bleeding toad was first described in 1838 by Tschudi from two specimens, probably from Cibodas. *Leptophryne cruentata* is the type species for the genus *Leptophryne* which was described by Fitzinger in 1843, at which time the name was still *Bufo cruentatus*. The bleeding toad has the synonyms *Bufo cruentatus* and *Cacophryne cruentata*. The name "cruentata" refers to Latin which means bleeding (Iskandar 1998). The taxonomic classification of this species belongs to the class Amphibians, family Bufonidae, genus *Leptophryne*, and species *Leptophryne cruentata* (Iskandar 1998). Molecular descriptions of bleeding toad specimens have been conducted to distinguish between *Leptophryne cruentata* and *Leptophryne javanica*. The results, based on the percentage comparison of uncorrected *16S* rRNA differences, amounted to 5.1-5.6 % (Hamidy et al. 2018).

Morphologically, the bleeding toad has a small slender body with small parotoid glands, no bony prominences on the skull, slightly bent fingers and toes, 3rd and 5th fingers webbed to the last subarticular tubercle, and a skin texture filled with small granular tubercles (Figure 4a) (Iskandar 1998; Hamidy et al. 2018). This species is characterised by its striking body colour, which is black with red and yellow patches (Iskandar 1998; Yazid 2007). However, our field observations show that there is a wider variety of colours, with at least six-colour combinations of bleeding toad patterns (Figure 4b).

The eggs were small and black. Tadpoles are similar to *Bufonidae* tadpoles, but the lower lip is bordered by papillae (Iskandar 1998). Tadpoles are small and bluish black in colour and are thought to have a short lifespan to become juvenile toads (30 days). In an experiment to collect stage 42 (Gosner) specimens, it took only 4 days for the tail to disappear completely. Tadpoles were found in shallow waters with a slow streamflow. The body sizes of males and females are quite different (Yazid 2007). Females have a larger body size than males. Female body size ranges from 24.51-46 mm with a body weight of 2.69-3.63 g, while male body size ranges from 20-30 mm with a body weight of 1.33-1.56 g (Iskandar 1998; Yazid 2007; Kusrini 2007b; Hasan 2022).

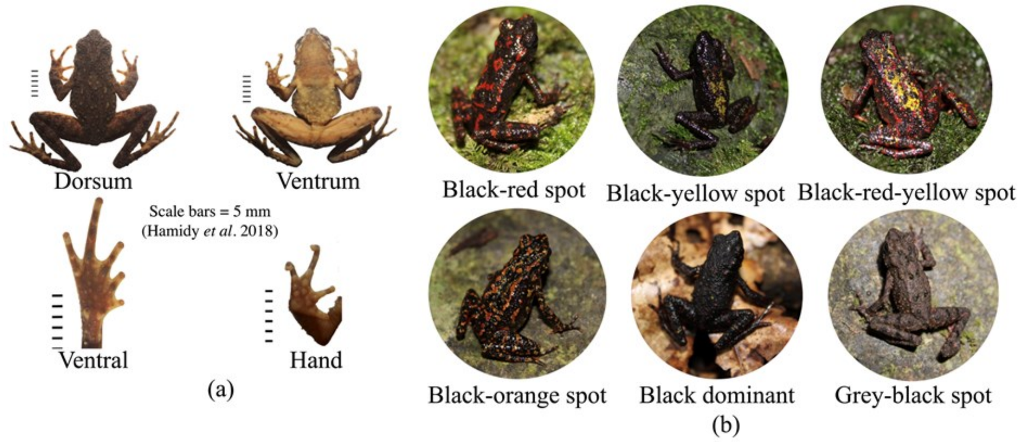


Figure 4. (a) Morphology of bleeding toad (Hamidy et al. 2018) and (b) showing various body pattern and color.

Geographical distribution

The bleeding toad is endemic to Java Island, and there are now 22 locations (Figure 5). In general, this species is primarily concentrated within two National Park regions, specifically in Gunung Gede Pangrango National Park (GGPNP) and Gunung Halimun Salak National Park (GHSNP). Within GGPNP, the bleeding toad can be found in the following areas: Curug Cibeureum, Rawa Denok, Selabintana, Ciapus, Lebak Saat, Curug Luhur, Cipelang, Perbawati, Curug Cikundul, Curug Pariuk, Curug Ceret, and Jajaway River (van Kampen 1923; Liem 1971; Iskandar 1998; Kusrini et al. 2005; Yazid 2007; Kusrini 2007b; Oktalina 2010; Ningsih et al. 2013; Kusrini et al. 2017; Permana et al. 2020; Setiawan et al. 2021; Kusrini et al. 2021; Hasan 2022). Meanwhile, its distribution within GHSNP includes Cikeris, Sagaranten, Gunung Botol, Curug Cibadak, Cikaniki, Lebak Banten, the eastern side of Kawah Ratu, and the Curug Heulang Hulu Ciliwung watershed (Kurniati 2003; Kurniati 2006; Kusrini et al. 2018; Kusrini et al. 2021). In addition to the national park areas, it is noteworthy that the bleeding toad has also been observed in the vicinity of the Waterfall at Taman Safari Cisarua-Bogor (Siregar 2016).

Habitat characteristics

This species lives in mountainous areas with clear streams and cold temperatures (Hasan 2022). Bleeding toads in the GGPNP can be found at altitude of 1370-2500 m asl. However, Kusrini et al. (2017) showed that the bleeding toad did not recover at an altitude of 2500 m asl (Lebak Saat), so the confirmed distribution started from 1370 to 2000 m asl. The bleeding toad in the GHSNP was found at an altitude of 1600-2200 m asl. (Kusrini et al. 2018).

The suitable temperature for the bleeding toad habitat is 10-25 °C and the humidity is 70-99 %. This species is mostly found along small rivers with slow currents of approximately 0.17-0.86 m sec^{-1}. River width ranges from 0.37-12.5 m, depth 30-50 cm, and with water pH 6. The river substrate was dominated by mossy rocks (*Sphagnum gedeanum*) and sand. The canopy density was 61-80 % dense–81-100 % very dense. Bleeding toads are often found on mossy rocks, river cliff wall holes and mossy weathered wood (Iskandar 1998; Yazid 2007; Oktalina 2010; Ningsih et al. 2013; Setiawan et al. 2021; Hasan 2022).

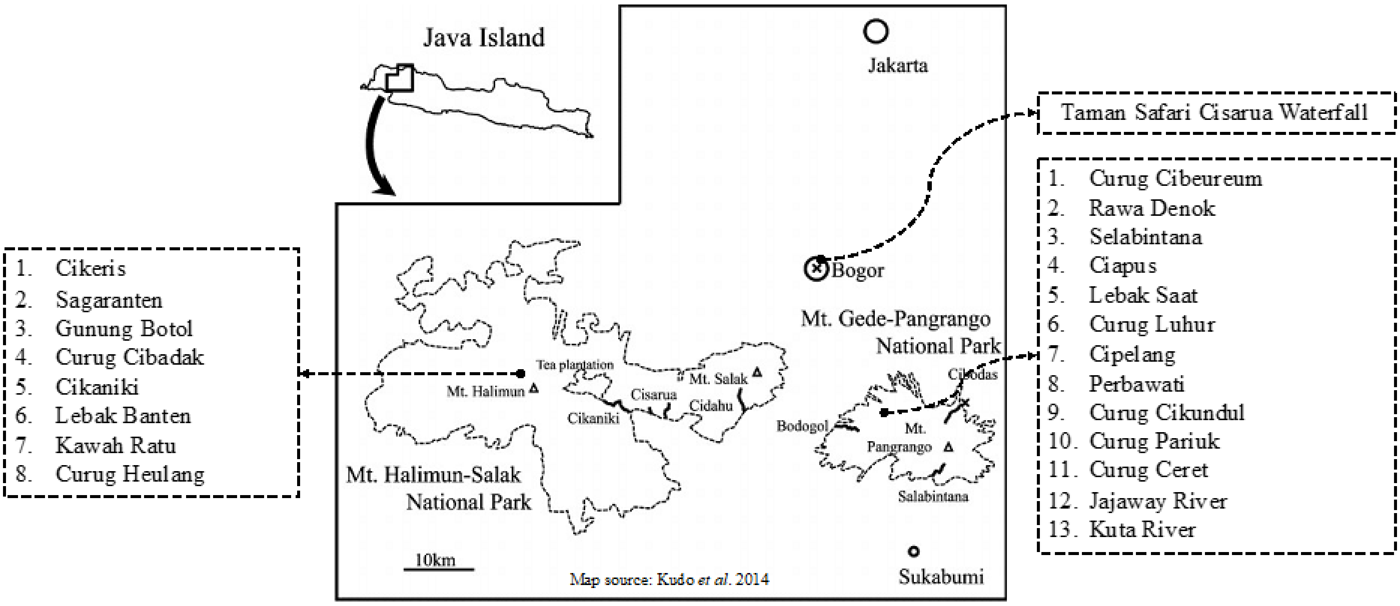


Figure 5. Bleeding toad geographical distribution (Map source: Kudo et al. 2014).

Encounter population record

After being described by Tschudi in 1838 from specimens from Cibodas, Liem (1971) found 149 individuals. Until 1998, bleeding toads were indicated to have experienced a population decline because they could not be found again around the Curug Cibeureum in GGPNP. (Iskandar 1998). This concern led Kusrini et al. (2005) to conduct another search for bleeding toad species in GGPNP and found four individuals. There are at least 7 literature mentions of bleeding toad encounters and the latest Hasan (2022) found 206 individuals in GGPNP area, with abundance ranging from 2.3-22.7 individuals/100 m and 410 tadpoles were found. Bleeding toad encounter records by year and distribution details from various sources (Table 2) (Liem 1971; Kusrini et al. 2005; Yazid 2007; Kusrini 2007b; Oktalina 2010; Setiawan et al. 2021; Hasan 2022).

Behaviour

Bleeding toads exhibit clustering behaviour in specific locations, predominantly demonstrating nocturnal activity but also being active during the day. Male individuals engage in calling activity at night in breeding sites. Bleeding toads are often associated with other toad species such as *Megophrys montana* and *Wijayarana masonii* (Yazid 2007; Hasan 2022). Bleeding toads mate throughout the year or season (Yazid 2007; Ningsih et al. 2013). Mating in bleeding toads occurs at night, and the eggs are affixed to rocks or plant roots in the form of mound-like structures that resemble grapes (Liem 1971). Tadpoles are found in small rivers (Iskandar 1998). According to Kusrini (2007b) from female specimens, bleeding toads have eggs that are uniform in size and are released simultaneously. Egg counts averaged 318.1 ± 59.9 (n=10) and could be up to 1200 eggs. The bleeding toad tadpoles in phases 24 -28 had a mean body length of 19.6 mm. (Ningsih et al. 2013). The dominant food of this species were *Hymenoptera* (60.38 %), *Optera* (7.55 %), *Orthoptera* (6.60 %), *Diptera* (6.60 %), *Lepidoptera* (4.72 %), *Hemiptera* (1.89 %), *Collembola* (1.89 %), and *Isopoda* (0.94 %) (Kusrini 2007b). Despite living in aquatic or riverine areas, this species forages on terrestrial habitats (Kusrini 2007b). In addition, according to Yazid (2007) Based on field observations, bleeding toads feed on winged ants, flies, and caterpillars. It is also known that bleeding toad tadpoles feed on organic materials such as food scraps from hikers in the river (Hasan 2022).

Protection status, threat, and bioprospecting

Bleeding toad is currently listed on the IUCN Red List as Critically Endangered (IUCN SSC Amphibian Specialist Group 2019). In 2006 Kusrini (2006) proposed the bleeding toad to be protected by Indonesian law. Therefore, the bleeding toad is currently the only protected amphibian in Indonesia. Bleeding toad has not been listed in the CITES (Convention on International Trade in Endangered Species) appendix. Bleeding toad threated by habitat disturbance by human activities or tourists who litter in several sites including Curug Cibeureum, Rawa Gayonggong, and Sungai Jajaway (Hasan 2022). Kusrini et al. (2008) found the infection of the fungus *Batrachochytrium dendrobatidis* (Bd) in bleeding toad although at low levels. This needs to be anticipated because Bd is one of the factors responsible for the decline in amphibian populations (De León et al. 2019). Two studies on the utilisation of bleeding toads have been conducted, with the potential of bleeding toad skin secretions as antibacterial and antifungal agents. Bleeding toad skin secretions have potential as anti-fungal *Trichophyton mentagrophytes* and anti-bacterial *Escherichia coli* and *Staphylococcus aureus* (Artika et al. 2015a, 2015b).

Research gaps and potential topics for future research

We were able to collect information on taxonomy and morphology, geographical distribution, habitat characteristics, encounter population records, behavior, protection status, threats, and bioprospecting. We used this limited information to conduct a research gap analysis. Identifying research gaps and potential areas for future research is crucial for advancing our understanding of the subject. By addressing these research gaps and pursuing these potential research avenues, we can contribute to a more comprehensive understanding of the bleeding toad ecology, conservation needs, and broader implications for biodiversity conservation in its habitat. Several fundamental

Table 2. Bleeding toad encounter record.

Year	Location												Total
	CCB	CCR	CP	RD	LS	RG	SJ	PB	CS	HL	SL	SKB	
1932									1				1
1959	5												5
1964	118				31								149
1972	1												1
1977	6							8	5		3		22
1978									1				1
1984												1	1
2003										2			2
2004	2												2
2005	4												4
2007	88												88
2007	15												15
2010	16			14		3							33
2021		26											26
2022	36	46	68	28		14	14						206
Total	291	72	68	42	31	17	14	8	7	2	3	1	

Curug Cibeureum (CCB); Curug Ceret (CCR); Curug Pariuk (CP); Rawa Denok (RD); Lebak Saat (LS); Rawa Gayonggong (RG); Sungai Jajaway (SJ); Perbawati (PB); Cisarua (CS); Halimun (HL); Salak (SL); Sukabumi (SKB). **Note**: The distribution locations are different from those in Figure 5 because there are several locations where bleeding toads can no longer be found.

research topics can serve to establish a solid scientific foundation for bleeding toad conservation, including ex-situ conservation (captive programs), reintroduction, habitat protection, survey and monitoring, trade, and sustainable use, as well as communication and education (Gascon et al. 2007; Davis et al. 2019; IUCN SSC Amphibian Specialist Group 2022). To fulfil the baseline information for bleeding toads, there were 11 essential topics, each with varying degrees of information sufficiency (sufficient, insufficient, and deficient). Identifying these sufficiency statuses can highlight data gaps and guide potential research topics for future investigation (Table 3).

Out of the 11 identified topics, only two currently hold a sufficient research status: taxonomy-morphology and protection status. This designation is attributed to the availability of ample data in these areas, particularly in relation to bleeding toad taxonomy and morphology, and the implementation of protective measures since 2006 (Kusrini 2006). An insufficient research status implies that research has been conducted, but there is still a lack of data. This inadequacy extends to topics such as geographical distribution, habitat characteristics, habitat suitability, bioprospecting, feeding behaviour, and population. Topics categorised as deficient indicate that there has been no prior study on bleeding toads in these areas, encompassing daily behaviour, reproductive behaviour, and threats. This paper also presents 18 potential research topics that could be conducted as part of fulfilling the bleeding toad baseline information. The substantial lack of fundamental data on the ecology and conservation of the bleeding toad poses challenges for formulating effective conservation policies. Consequently, the outcomes of this study can serve as a valuable guide for researchers and policymakers, aiding in prioritising research endeavours that are imperative for a more comprehensive understanding of bleeding toad ecology and facilitating effective conservation strategies.

CONCLUSIONS

Our findings indicate a scarcity of literature on bleeding toads, encompassing merely 20 reviews, predominantly sourced from grey literature. This highlights the precarious conservation status of bleeding toads and their relative neglect in scholarly investigations. Additionally, our scrutiny reveals gaps in essential domains including taxonomy, morphology, geographical distribution, habitat characteristics, encounter records, behaviour, protection status, threats, and bioprospecting. Notably, only two of the 11 thematic areas achieved adequate coverage, highlighting the significant research gap. Our insights emphasize the imperative for expanded research endeavours in this domain. We have pinpointed approximately 18 prospective research domains pivotal for augmenting the knowledge base on bleeding toads. Such revelations offer indispensable insights for academics and policymakers alike, aiming to mitigate the critical endangerment of bleeding toads and devise efficacious conservation measures.

AUTHOR CONTRIBUTION

R.K.T designed the research, collected, analysed, and wrote the manuscript, M.D.K, A.M, D.A.R wrote and review the manuscript.

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Table 3. Research gaps and potential topics for future research.

No.	Research topics	Research Status	Data deficiency and potential topics for research
1	Taxonomy and morphology	Sufficient	[1]Additional morphological data may include an analysis of the coloration patterns exhibited by bleeding toad and [2]population genetics in each habitat
2	Protection status	Sufficient	-
3	Geographical distribution	Insufficient	[3]Insufficient distribution data exists for the southern and western regions of GGPNP, and a notable paucity of data is evident in the case of GHSNP. [4]Species distribution modelling, [5]dispersality or local migration
4	Habitat characteristics	Insufficient	[6]It is imperative to conduct further validation of the utilization of waterfall habitats, fast and slow stream river, and lake
5	Habitat suitability	Insufficient	[7]A dedicated investigation of a specific habitat location utilizing high-resolution data has not been conducted
6	Bioprospecting	Insufficient	[8]Need to explore other potentials
7	Feeding behaviour	Insufficient	[9]This can be complemented by an exploration of the daily feeding requirements
8	Population	Insufficient	The current research is only bleeding toad encounter records. [10]Population estimation and carrying capacity have not yet been documented [11]Captive breeding
9	Daily behaviour	Deficient	[12]Comprehensive data regarding daily behaviour spanning a 24-hour period, [13]movement patterns, [14]bioacoustic characteristics,
10	Reproduction behaviour	Deficient	[15]Information pertaining to mating stages, [16]selection of mating and nesting sites, [17]reproductive system, egg clutch per year, first breeding age of males and females, maximum age, sex ratio at birth and mortality.
11	Threats/ Catastrophes	Deficient	[18]No research has been undertaken to assess the sensitivity of bleeding toad to human disturbance, biotic environmental alterations such as climate change, and volcanic eruption.

CONFLICT OF INTEREST

There are no conflict interests.

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