**Lessons from practitioners for designing and implementing effective amphibian captive breeding programmes**

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Supplementary Material 1 Interview guide.

The interview guide was developed in collaboration with Jeff Dawson at Durrell Wildlife Conservation Trust, Kevin Johnson at Amphibian Ark and Andrew T. Knight at Imperial College London. It is based on the recommendations of Dillman et al. (2014). The guide was piloted with three managers and subsequently refined. Because of the small sample size, the pilot interviews were used in the analysis (Brinkmann and Kvale, 2015)

**Disclaimer and introduction**

Introduce yourself.

Ask for consent to be recorded.

The goal of the research: We are examining the limitations of amphibian captive breeding programmes in tropical countries to understand how the international conservation community can provide better, targeted resources that are really important and needed.

The purpose of the interview: We want to know what you think is important for your project, and what you think is not working. We ask you to speak freely about barriers, limitations and failures.

Failures: We believe that understanding failures or problems is essential to learning and developing better, more effective programmes, although we understand it is not easy. This opportunity for learning is lost if we do not talk about failures.

The structure of the interview: It will mostly be conversation. I will also ask you to rate a few items on a scale of 1–5 (responses have to be whole numbers).

**Barriers and enablers**

Background information:

* What is the name of your programme?
* Confirm what species they work with.
* Why did you set up the programme? What was your initial goal? (Try to get a detailed response.)
* Has the goal changed? Was it achieved?
* Plans for the future

Barriers and limitations:

* Resources definition: A materialistic or non-materialistic infrastructure, equipment, activity, plan, skill or any other factor which influences the running of the project. (Other than this definition, do not give examples because that might bias the response. Instead keep asking ‘why?’ or ‘for what?’)
* What resources are the most important for the success of your programme? Include both resources you have and resources you need.
* Split the resources into categories and subcategories. Get them to pick the top 5 most important categories if they mention more than that. Then ask them to score them on a scale of 1–5 in terms of sufficiency, whereby 1 is they do not have any, 5 is they have all they need. Start with finance (whether this was mentioned or not).
* What are the main barriers to the success of your programme and to achieving your goals?
* What limitations and difficulties did you experience when you first set up the programme?
* What have been your most significant failures?
* What do you do when you encounter a failure? How do you try to overcome it?
* Describe your in-situ conservation work (if any) or collaborations with in situ projects. Are threats facing some or all of your species in the wild being mitigated? (Future plans can also tie in with this.)

**Partnerships**

* Who are your main partners and collaborators? (This can be any external support for the programme, both present and past. We do not need to get all partners, just the most important ones.)
* Who are your top three most important partners/collaborators (if they mentioned more than 3)?
* What types of resources do these partners provide?
* What amount of funding do you receive from these top three collaborators/ partnerships in USD annually, if any?
* What is your level of engagement with these partners?
* How do you feel your partnerships are going (if they have not already talked about this)?
* How do you find their reporting/monitoring process (if they have one)?
* How do you find the reporting/monitoring process of the Amphibian Ark (if not included in the above)?
* What is the average duration of your partnerships?

|  |  |  |  |
| --- | --- | --- | --- |
| Partner | Type of resource | Amount in USD for the last year | Comments |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |

* Can you talk about the level of support you receive internally (if part of a bigger organization)?

Example spreadsheet

**Key facilities and plans**

On a scale of 1–5 how developed are your following plans? They do not have to be written plans. Try to get them to decide based on how they interpret it.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | 1 | 2 | 3 | 4 | 5 |
| Species conservation action plan |  |  |  |  |  |  |
| Studbook |  |  |  |  |  |  |
| Husbandry guidelines |  |  |  |  |  |  |
| Biosecurity protocol |  |  |  |  |  |  |
| Management strategy |  |  |  |  |  |  |
| Strategies to deal with failures |  |  |  |  |  |  |
| Education, outreach and engagement strategy |  |  |  |  |  |  |
| Financial plan |  |  |  |  |  |  |
| Exit strategy |  |  |  |  |  |  |

Example spreadsheet

On a scale of 1-5 how good is your access to and availability of the following facilities/equipment?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 |
| Access to lab facilities |  |  |  |  |  |
| Natural history information of your species |  |  |  |  |  |
| Access to quarantine facilities |  |  |  |  |  |
| Access to a vet |  |  |  |  |  |
| Appropriate system for controlling environmental parameters |  |  |  |  |  |
| Available founding population |  |  |  |  |  |
| Appropriate nutritional food for your amphibians |  |  |  |  |  |
| Enrichment of enclosures which imitate their natural habitat |  |  |  |  |  |
| Clean, running water |  |  |  |  |  |
| Electricity |  |  |  |  |  |
| Internet access |  |  |  |  |  |

Example spreadsheet

**Progress of programmes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Yes | No | Unsure | Not relevant to the programme |
| Have you bred captive offspring from one or more of your founding populations? |  |  |  |  |
| Have you bred offspring from captive bred individuals in one or more of the populations? (F2) |  |  |  |  |
| Have you released captive bred individuals from one or more of your populations into the wild? |  |  |  |  |
| Have your releases had a positive impact on the wild population (if applicable)? |  |  |  |  |
| Do you or your partners monitor and evaluate the status of any of your populations in the wild? |  |  |  |  |

Example spreadsheet

**Programme structure**

Background details:

What is your annual budget?

Are you part of a bigger organization?

What type of organization?

Where are you from? (Are you from the country of the breeding programme?)

Where are you personally located (do they work on-site, in an office)?

Do you speak the local language?

What year did the programme start?

How many species did you start with?

How many species do you have now?

How many full-time staff do you have now?

How many individual amphibians do you house?

How many individual amphibians do you have the capacity to house?

Do you have volunteers? (yes/no/sometimes)

Are your staff mainly local or international?

On a scale of 1–5, how successful do you think your programme is (1 being not at all successful and 5 being extremely successful)?

**Thank you and goodbye**

Do you have any feedback?

Can we send you some follow-up questions if we think of something we missed?

## Supplementary Material 2 Detailed methods.

### Framework analysis

This is a description of how I followed the seven-stage process as outlined by Gale et al. (2013) for the purpose of this study.

* 1. Transcription: I produced verbatim transcripts of all interview recordings from start to finish. Another three follow-up emails and four interview summaries were also included.
  2. Familiarization: I familiarized myself with the materials by listening to the recordings and reading the transcripts.
  3. Coding: We used the following, non-exclusive criteria for whether to code a passage as barriers and enablers, partnerships or failures. Resources were analysed under barriers and enablers as these are interchangeable. I used open coding, suitable for an inductive approach (Gale et al., 2013). This means I coded each selected text with a short description that I believed captured the topic addressed. A subset of four interviews was coded by an assistant researcher (Gale et al., 2013).
  4. Development of a working analytical framework: I compared each passage of coding with the codes of the assistant researcher for the selected interviews, and we discussed and agreed on the most precise codes. I developed a framework of all codes, with the input from the assistant researcher, who reviewed the framework and confirmed its consistency with his interpretation. This was done to challenge my observer bias and provide an alternative perspective on the material (Gale et al., 2013)
  5. Application of the analytical framework: I re-coded the interviews, using the predetermined codes from the analytical framework. Passages of text were coded at all the relevant levels, i.e. sometimes overlapping (Ritchie and Spencer, 1994) To illustrate the process of coding, I provide an example of a statement which I coded under balancing tasks, government relations and developing partnerships:

“Yeah, one main thing that is only for me a problem is like I’m not octopus, how do you say in English… Yeah because I need to write applications, write reports, to work with my PhD, to coordinate things in [redacted]. Meetings with government in [redacted], meetings with other institutions, now I have two kids so, it’s difficult to increase.” (P9)

* 1. Charting of the data into the framework matrix: For this step, responses provided by each participant for each category is charted into a framework matrix. Because of resource limitations, data in the charts produced in NVivo v11 Plus (QSR International) was not summarized. This did not reduce the level of interpretation as I was the only analyst and was familiar with all the data.
  2. Interpretation of the data: Gale et al. (2013) highlight that interpretation of rich data can:

“Go beyond description of particular cases to explanation of, for example, reasons for the emergence of a phenomena, predicting how an organisation or other social actor is likely to instigate or respond to a situation, or identifying areas that are not functioning well within an organisation.”

I developed an operational model, which concisely captures my interpretation of the information based around the analytical framework.

Supplementary Material 3 Information on data quality.

### **Information on quality of process**

Information on the 32 steps identified by Tong et al (2007) for reporting on qualitative analysis. These steps are divided under three domains; research team and reflexivity, study design and analysis and findings.

|  |  |
| --- | --- |
| Domain 1: Research team and reflexivity | |
| *Personal characteristics* | |
| 1. Interviewer/ facilitator | The principal investigator (PI) conducted interviews in English (n *=* 20), and an assistant researcher (AR) conducted interviews in Spanish (n *=* 5). |
| 2. Credentials | The PI was an MSc student and this study formed her thesis. Contributing authors were supervisors based at Imperial College London, Durrell Wildlife Conservation Trust, and the Amphibian Ark. |
| 3. Occupation | See above. |
| 4. Gender | The PI is female, the supervisors and the AR are male. |
| 5. Experience and training | The PI had previous experience conducting questionnaire studies as part of her degrees, but no prior experience in interviewing. Supervisor Andrew T. Knight specializes in social science and contributed to the development of the methods. |
| *Relationship with participants* | |
| 6. Relationship established | The PI had no prior relationship with any of the participants. Supervisors introduced the PI to any participants they were in communication with, to increase response rate. The AR knew many of the Latin American managers. Latin American participants were therefore always given the option of doing the interview with the PI in English prior to being introduced to the AR. |
| 7. Participant knowledge of the interviewer | We did not present the study as a student project, unless a participant specifically asked, as this was anticipated to reduce response rate. We presented the study as a collaboration between Durrell Wildlife Conservation Trust, Amphibian Ark and Imperial College London. These institutions perceive their reputation as predominantly positive amongst captive breeding programmes, so this was done to increase response rate and not expected to deter programmes. The study was introduced as a means of understanding the needs of captive breeding programmes to make recommendations on increased capacity and support for these. The PI did not reveal any personal characteristics to reduce bias and enforce a sense of anonymity. When asked, the PI would introduce herself to establish trust. |
| 8. Interviewer characteristics | The PI’s characteristics and biases are reported in the supporting information. |

|  |  |
| --- | --- |
| Domain 2: Study design | |
| *Theoretical framework* | |
| 9. Methodological orientation and theory | Methodology: Inductive thematic analysis (also called qualitative content analysis). Method: the framework method. |
| *Participant selection* |  |
| 10. Sampling How were participants selected? | The PI identified participants from the Amphibian Ark database. Contact details of managers whose projects were not recorded in the database were provided by individual authors. All known managers of amphibian captive breeding programmes in the tropics were invited to get as high a representation of the population as possible. |
| 11. Method of approach | The PI invited participants via e-mail, which was designed following the guidelines of Dillman et al. (2014). The PI sent three emails: one invitation, one reminder and one last chance invitation. E-mails were personally tailored to the manager and the project. The PI and AR conducted interviews via Skype to landline or mobile phone, or online calling services: Skype online calls, FaceTime and Telegram. One interview was completed in person. |
| 12. Sample size | Of the 50 invited managers, 25 participated in the study (response rate 50%). Audio recordings of four participants were corrupted or lost. Because conversations were tailored to the interviewee and their time restrictions, not all managers completed all of the questions (Tong et al., 2007). The experiences of two managers were not relevant to all aspects of the study as their organizations acted as facilitators and did not keep amphibians themselves. In these cases, only the barriers/enablers section was used for analysis. |
| 13. Non-participation | Three participants responded initially but did not complete an interview. This was in one case identified as time constraints, which was possibly the case for the other two, as the managers in general were busy and sometimes struggled to make time for the interview amongst their daily tasks, sometimes leading to delays or rearrangements of interviews. The PI developed a questionnaire as an attempt to address non-response bias, to identify reasons for not completing an interview, and to include responses of managers who preferred the anonymity and flexibility of questionnaires. Differences between phone and questionnaire survey participants could then be analysed. However, just one questionnaire was received and thus not included in the analysis. This is probably because managers are willing to participate, having done so over phone, or some email addresses could be outdated (three email addresses were identified as non-functional). Although the reason for non-response was not established, respondents and their programmes were diverse in terms of geographical locations, language proficiencies, parental institutions and organizational structures, and thus none of these factors were likely a barrier to participation. |
| *Setting* |  |
| 14. Setting of data collection | Over phone or internet. A few interviews were conducted with video, but in most cases, internet connection was too poor to support video calls. |
| 15. Presence of non-participants | In four cases, both the PI and the AR participated in the call, for training purposes, but only one of them actively conducted the interview. Participants had consented to the situation prior to the interview. |
| 16. Description of sample | Participants were from 15 countries in Latin America (9), Africa (3) and Asia (3). Women were especially encouraged to participate and made up 20% of participants. The age of participants was not recorded, but early-career, mid-career, late-career and retired managers all participated in the study. Interviews were conducted during 13 May–22 June 2017. |
| *Data collection* |  |
| 17. Interview guide | The PI developed an interview guide in collaboration with the supervisors based on recommendations of Brinkmann & Kvale (2015) and Dillman et al. (2014). Because of the small sample size, the PI piloted the guide on the first three managers and included these interviews in the analysis, with follow up questions developed after the pilot emailed to the managers. This did not appear to have major implications to the information due to the inductive nature of the study, and the biggest changes to the guide was the exclusion of unnecessary questions, and restructuring of their order. |
| 18. Repeat interviews | The PI redid one pilot interview. |
| 19. Audio/visual recording | The interviewer audio-recorded the interviews, but failure of equipment rendered four recordings unusable. |
| 20. Field notes | The interviewer made notes for interviews for which recordings were corrupted or lost. Further ideas and emerging themes were noted as they arose. Notes about the flow of the conversation were not made, as the audio recordings were used to re-evaluate the data during analysis. |
| 21. Duration | The shortest interview lasted 40 minutes and the longest lasted 2 hours (the first pilot). Most interviews took 1–1.5 hours. The duration was influenced by the amount of detail provided by the participant. |
| 22. Data saturation | The programmes were so diverse that every programme would generally approach at least one unique category. However, the last interviews conducted mainly covered general themes with few new additions. More interviews could not be conducted as the interviewee population had been exhausted. |
| 23. Transcripts returned | Because of time restrictions of both researchers and participants, transcripts were not returned to participants for checking. However, the PI identified three critical barriers to each programme from each interview and returned to the participants who were given the opportunity to make suggestions for changes or clarify the findings. If no response was received, the recorded data was used. Although participant checking can shift authority from the researcher to the participant (Lacey & Luff, 2001), it was helpful to avoid misinterpretation based on linguistic barriers or lack of expert knowledge. |
| Domain 3: Analysis and findings | |
| *Data analysis* |  |
| 24. Number of data coders | The PI coded every interview. One External Researcher (ER) also coded a subset of four interviews, and provided input on the analytical framework. |
| 25. Description of the coding tree | The analytical framework is presented in Supplementary Table 1. |
| 26. Derivation of themes | The PI used data from one question (What are the most important resources to your programme?) to develop a framework of resources. All answers provided in section 1 were then analysed and additional themes and categories developed around the initial framework which was expanded to represent the unit of barriers/enablers (as this was found to be interrelated with resources), and two additional units were added: failures and partnerships. The PI coded all information relating to the themes and categories, whether it appeared as a barrier, enabler or a statement, in order to assess relative importance and to include as much information on the topic as possible. |
| 27. Software | The PI used *NVivo v.11 Plus* (QSR International, Doncaster, Australia) to analyse the data from the barriers and enablers, and partnerships sections of the interviews. Excel was used to summarize and tally quantitative information from the remaining sections. |
| 28. Participant checking | Apart from the critical barriers (see point 23), participants did not provide feedback on the overall findings of the study. However, the findings were peer-debriefed (Lacey & Luff, 2001) with the AR and supervisors at Durrell Wildlife Conservation Trust and Imperial College London to challenge or confirm the PI’s interpretation of the data. |
| *Reporting* |  |
| 29. Quotations presented | Quotes were carefully selected to support general findings rather than illustrate extremes. Participant numbers were not used, to ensure data confidentiality. |
| 30. Data and findings consistent | The findings are rooted in the results presented in the analytical framework. |
| 31. Clarity of major themes | Major themes did not present much of a guide for selection of data, as most themes were addressed by most respondents. Therefore, major categories were chosen to guide the interpretation of the data. |
| 32. Clarity of minor themes | Minor themes can be fully examined in the analytical framework (Supplementary Material 4), and Fig.3 presents both major and minor critical barriers. |

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### **Observational standpoint**

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Acknowledging the impact of personal biases on qualitative research, and reporting on the researcher’s characteristics and biases increases transparency of the research process and allows the reader to assess the dependability of the research (Tong et al. 2007). Here I report on my observational standpoint according to the criteria outlined by Tong et al. (2007)

### My background

I am a 28-year-old Danish woman, residing in the UK. I grew up in a working-class home in a small city in Denmark. In 2012 I pursued an undergraduate degree in Integrated Wildlife Conservation at University of the West of England in Bristol. This course focused heavily on the integration of conservation with the sustainable development of human communities. My passion for this aspect of conservation brought me to Imperial College London where I study MSc Conservation Science, for which this thesis is submitted. I have travelled and volunteered for 4 years and been to 37 countries in North America, Latin America, Europe, South East Asia and Australia. In some of these countries I have worked or volunteered for extended periods of time. I have a good understanding of global perspectives on conservation, and the difficulties faced by many in countries with different resource availabilities.

### Prior assumptions and experience

I have been interested in amphibians since a visit to Ecuador in 2011. This interest has grown and I have focused my career on amphibians increasingly in the last few years. In 2016 I developed and led amphibian and reptile surveys during work experience in Costa Rica. However, I have had little interaction with other amphibian experts, and my limited knowledge on the topic is self-taught. I have never kept amphibians or similar species such as fish, and I know very little about amphibian husbandry, biology or behaviour. I have had no previous interactions with the amphibian community that has been the subject of this study. My personal motivations for conducting this study lie in my interests both in amphibians and in human–wildlife interactions, the latter of which may have influenced my interpretation of the results.

The idea for the study was introduced to me by my external supervisors, with whom I developed the research question and methods. They presented me with questions for investigation and some likely outcomes, which were used to develop the interview guide, along with themes occurring in the literature. The Amphibian Ark, a partner of the study, provided support for amphibian captive breeding programmes and thus wanted to use the outcomes of the study to understand how they can improve partnerships and support for amphibian captive breeding. However, I wanted to reduce preconceived biases, and adopted an inductive approach that allowed the identification of themes and categories of importance to arise from the narrative of the participants. From this perspective, my lack of prior knowledge of the specific topic of investigation was probably beneficial, although it may have led to misinterpretation of some of the information.

### Interaction with participants

Interactions with participants occurred over e-mail, and all communication was tailored to each participant to increase response rate and build trust (Dillman, 2014). Participants appeared comfortable with the conversation and questions, and were willing to share sensitive information. The lack of prior relationships with participants, and perhaps my gender and the fact that most interviews were completed without video, appeared to enforce the sense of confidentiality and openness. Participants often expressed optimism about the opportunity to share their experiences and ideas. I allowed participants to pursue topics and ideas based on their perceived importance and did not interrupt or move on unless a participant had expressed what they wanted, or were addressing topics completely irrelevant to the research question. I expressed optimism and empathy and took care in choosing additional questions throughout the conversation to maintain a level of trust and comfort.

As the project was promoted as an Amphibian Ark collaboration, mentions of contributions to a programme through Amphibian Ark partnerships were possibly over-emphasized. All programmes who mentioned the Amphibian Ark did so in a neutral or positive light, and the association of the study with the Amphibian Ark was not likely to defer participants.

### Training of interviewers

I had no prior experience in conducting interviews. The study aimed to collect explicit rather than implicit information (although some implicit ideas emerged from the data), and the use of visual and linguistic cues was not an integral part of the study. I prepared myself for conducting the interviews by reading literature on interview methods (Brinkmann & Kvale, 2015) and by consulting my supervisor Andrew T. Knight, who has prior interview experience. I practiced my methods for the pilot interviews, two of which were conducted with partners of Durrell Wildlife Conservation Trust and Amphibian Ark, and who were willing to evaluate the questions, provide feedback and reply to follow-up questions at a later stage. I then trained the assistant researcher by introducing him to the concepts of an inductive study, highlighting and explaining prompts and providing feedback on his interview recordings.

## Supplementary Material 4 Data on critical barriers.

|  |  |  |  |
| --- | --- | --- | --- |
| **Critical barrier summary** | **Category 1** | **Category 2** | **Category 3** |
| Display value | Public relations |  |  |
| Climate - have to change environment | Captive environmental control systems |  |  |
| No in situ links | Allocation of resources for in situ conservation | Wild habitat conditions |  |
| Lack of species information for setting clear plans and prioritization | Species-specific information | Prioritization of species |  |
| Maintenance of facilities and equipment | Infrastructure for captive breeding | Captive environmental control systems | Enclosures |
| Permits and government relations | Government relations |  |  |
| Information on conditions of reintroduction habitat | Availability of information | Wild habitat conditions |  |
| Lack of breeding in indoor facilities | Captive environmental control systems |  |  |
| Local perceptions at reintroduction sites | Public relations | Wild habitat conditions |  |
| Conflict with authorities | Government relations | Ownership |  |
| Inability to recreate environmental conditions for breeding | Captive environmental control systems | Species-specific information |  |
| Lack of funding for staff salaries and resulting high staff turnover | Availability of financial resources | Number of staff | Staff expertise |
| Dependence on leadership from one individual | Leadership | Staff expertise |  |
| Habitat conditions not suitable for reintroduction | Wild habitat conditions |  |  |
| Institutional and public interest in amphibians | Public relations | Internal support |  |
| Lack of information on the species | Species-specific information |  |  |
| Permits and government relations | Government relations |  |  |
| Funding for ex situ components | Allocation of resources for in situ conservation | Wild habitat conditions |  |
| Lack of planning/prioritization of species | Strategies and plans | Prioritization of species |  |
| Land use of habitat for reintroduction | Wild habitat conditions |  |  |
| Government and public perceptions and relations | Government relations | Public relations |  |
| Available information on the species | Species-specific information |  |  |
| Complexity in breeding high number of species | Focus of the programme | Balancing tasks | Allocation of resources for in situ conservation |
| Specialized equipment | Access to equipment | Captive research |  |
| Government bureaucracy and perceptions | Government relations | Bureaucracy |  |
| Suitable habitat conditions, danger of fieldwork | Wild habitat conditions | Access to field sites | Political and socio-economic situation |
| Staff willingness and engagement | Staff willingness |  |  |
| Institutional support/display value | Internal support | Public relations |  |
| Bureaucracy delaying access to equipment | Access to equipment | Bureaucracy | Government relations |
| Information on species for prioritization | Species-specific information | Prioritization of species |  |
| Access to field sites | Access to field sites |  |  |
| Bureaucracy and permits | Government relations | Bureaucracy |  |
| Access to equipment | Access to equipment |  |  |
| Government relations and permits | Government relations |  |  |
| Funding model not working | Biocommerce |  |  |
| Threat to species not mitigated | Wild habitat conditions | Bureaucracy |  |
| Finding reintroduced individuals to monitor | Monitoring populations | Field research |  |
| Cost and availability of equipment | Access to equipment | Availability of financial resources |  |
| Time for fieldwork | Field research | Balancing tasks | Allocation of resources for in situ conservation |
| Poor information on captive breeding needs, mainly nutrition | Availability of information | Food/nutrition |  |
| A focus on in situ conservation, not ex situ | Mindsets |  |  |
| Ethical concerns of collecting rare specimens and reducing genetic diversity | Mindsets | Availability of founding individuals | Allocation of resources for in situ conservation |
| Political crisis | political and socio-economic situation | Government relations |  |
| Access to the field, materials and funding (transactions) | Access to field sites | access to equipment |  |
| Specialized cooling equipment | Captive environmental control systems |  |  |
| Lack of reintroduction expertise | Reintroduction expertise |  |  |
| Lack of staff | Number of staff |  |  |
| Unknown causes of amphibian mortalities | Diseases |  |  |
| Ownership and legal status | Ownership | Bureaucracy |  |
| Habitat conditions not suitable for reintroduction | Wild habitat conditions |  |  |
| Staff leadership and motivation | Staff willingness |  |  |
| Facilities | Infrastructure for captive breeding |  |  |
| Partnerships: conflicts and need for in situ partners | Problems in partnerships | Developing partnerships |  |
| Lack of founding individuals and breeding success | Availability of founding individuals | Species specific information |  |
| Available resources for in situ conservation | Allocation of resources for in situ conservation |  |  |
| Technical support on reintroduction protocols | Reintroduction expertise | Protocols |  |
| Availability of habitat for reintroduction | Wild habitat conditions |  |  |

|  |  |
| --- | --- |
| **Sum of categories** | |
| Wild habitat conditions | 10 |
| Government relations | 9 |
| Species specific information | 6 |
| Allocation of resources for in situ conservation | 6 |
| Captive environmental control systems | 6 |
| Public relations | 5 |
| Access to equipment | 5 |
| Bureaucracy | 5 |
| Access to field sites | 3 |
| Prioritization of species | 3 |
| Internal support | 2 |
| Availability of financial resources | 2 |
| Availability of information | 2 |
| Mindsets | 2 |
| Political and socio-economic situation | 2 |
| Number of staff | 2 |
| Staff expertise | 2 |
| Balancing tasks | 2 |
| Infrastructure for captive breeding | 2 |
| Staff willingness | 2 |
| Reintroduction expertise | 2 |
| Ownership | 2 |
| Availability of founding individuals | 2 |
| Monitoring populations | 1 |
| Field research | 1 |
| Facilities and plans | 1 |
| Focus of the programme | 1 |
| Captive research | 1 |
| Enclosures | 1 |
| Diseases | 1 |
| Food/nutrition | 1 |
| Leadership | 1 |
| Developing partnerships | 1 |
| Problems in partnerships | 1 |
| Protocols | 1 |

Supplementary Table 1 The analytical framework.

Analytical framework developed during the fourth stage of the framework analysis, for the categorization of information from the interviews (Gale et al. 2013). Blue boxes are most common or critical barriers referred to in table 1. Numbers in the column in the right represent the number of sources in which a category was addressed. Information in dashed boxes was addressed under a different theme.

|  |  |  |  |
| --- | --- | --- | --- |
| Facilities | The physical environment in which the amphibians are kept (excluding equipment) | | 24 |
| Category | Subcategory | Description |  |
| Infrastructure for captive breeding |  | Building or other facilities for the amphibians, live food, staff, visitors and equipment | 21 |
|  | Space for amphibians and live food | Available space for keeping and breeding amphibians and their live food | 15 |
|  | Exhibition displays | Displays in exhibition areas in publicly available facilities | 11 |
|  | Design and building phases | The stage at which the building is in, and the need to redo things if not done adequately the first time | 8 |
|  | Laboratory facilities | Available laboratory facilities in the building, or access to it externally | 7 |
|  | Tailored, flexible facilities | The appropriateness of the facilities to the specific needs of the species and flexibility to adapt to different species' needs and to seasonality and social settings | 6 |
|  | Quarantine | Available quarantine facilities | 4 |
|  | Electricity | Electricity to run equipment | 3 |
|  | Water | Clean, running water | 2 |
|  | Backup systems | Systems that take over if primary systems fail, like electricity or water | 2 |
|  | Internet | Access to appropriate internet | 1 |
| Ownership |  | Ownership of the land, building and specimens | 7 |
| Biosecurity |  | Biosecure facilities with appropriate protocols which are implemented | 7 |
| Climate |  | Similarities/differences between climates in the location of the facilities and in the species range | 5 |
| "All eggs in one basket" |  | Options for holding captive populations at partner institutions to increase security for the captive population as a whole | 5 |
| Safety |  | Safety of facilities, or their locations, to staff, visitors and amphibians | 2 |
| Enrichment |  | Naturalization of the enclosure, to mimic the wild habitat | 2 |
|  |  |  |  |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Equipment | Equipment for the facilities or the field | | 23 |
| Category | Subcategory | Description |  |
| Captive environmental control systems |  | Equipment to ensure optimal environmental conditions for the species | 18 |
|  | Water quality | Filters, reverse osmosis and other equipment to ensure water quality | 12 |
|  | Lights | UVB lights | 10 |
|  | Temperature | Air-conditioning, heating and other equipment to control temperatures and their variations | 7 |
|  | Breeding triggers | The ability of equipment to change the environmental or social conditions to trigger breeding | 3 |
|  | Humidity | Misting systems and other humidity control | 2 |
| Food/nutrition |  | Use of self-bred, wild sourced and purchased food including invertebrates and supplements | 14 |
| Enclosures |  | Tanks and containers for keeping amphibians, and the design of these | 11 |
| Access to equipment |  | Access and availability of equipment, imported or in-country | 9 |
| Field equipment |  | Equipment needed for fieldwork and research | 4 |
| Monitoring equipment |  | Equipment for monitoring the health and reproductive status of the amphibians | 3 |
| Medicine |  | Antibiotic, anti-fungal and anti-parasite medication amongst others | 1 |
|  |  |  |  |
| Social relations | Perceptions and awareness of the programme and of amphibians on a wider scale | | 23 |
| Category | Subcategory | Description |  |
| Government relations |  | Relationship with the government | 19 |
|  | Government support | The level and type of support received from governmental bodies | 17 |
|  | Permits | Availability of permits and the duration of their processing | 11 |
|  | Government perceptions | The perceptions of governmental bodies and their influence on the programme | 9 |
|  | Legislation and policy | The legal frames within which the programme must operate, or advocate for their changes | 9 |
| Public relations |  | Education and engagement of the public, stakeholders and communities | 19 |
|  | Education and engagement | The use of education and engagement to build support for the programme, to promote sustainable behaviours and to teach about amphibians | 18 |
|  | Public and community perceptions and support | Perceptions and other actions of the public and communities, and how this influences the programme and sometimes its support from other partner institutions including governments | 13 |
| Publicity |  | Spreading the word of the importance and work of the programme and of the global amphibian crisis | 7 |
| Livelihoods |  | Financial costs to or opportunities for the public/communities in relation to the programmes activities and goals | 6 |
| Pride and flagship status |  | Pride in a species and its impact on attitudes and perceptions | 4 |
| Impact evaluation |  | Evaluating whether awareness has had the intended impact | 1 |
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| Research | Any research carried out or needed by the programme | | 23 |
| Category | Subcategory | Description |  |
| Field research |  | Research on species distribution, status, habitat conditions, environmental parameters and behaviour | 13 |
| Monitoring populations |  | Monitoring wild and released populations: population status, ability to survive in the wild and diseases | 13 |
| Reintroductions |  | Research on when and how to perform reintroductions, or on captive individuals' suitability for reintroductions | 12 |
| Ex situ research |  | Research on species in captivity | 8 |
| Chytrid |  | Field and lab research on prevalence of chytrid fungus and methods for mitigating chytrid related issues | 8 |
| Genetic |  | Research on the genetic makeup of wild and captive populations to maintain genetic diversity and resolve taxonomic issues | 3 |
| External researchers |  | National and international researchers who conduct research that can be used by the programme | 3 |
| Prioritization of research |  | The allocation of resources for research by the institution/programme | 2 |
|  |  |  |  |
| Staff | Manpower for the running of the programme | | 22 |
| Category | Subcategory | Description |  |
| Number of staff |  | Amount of permanent workforce | 16 |
|  | Prioritization of staff | Allocation of dedicated staff, and their time for amphibians in mixed species institutions such as zoos | 5 |
|  | Staff retention and turnover | Ability to provide salaries and opportunities for staff, and other issues regarding retention of staff and turnover | 4 |
| Staff training/education |  | Internal and external training and/or education of staff and its impact on overall amphibian expertise | 16 |
| Staff expertise |  | Staff knowledge, experience and professionalism | 13 |
| Volunteers/interns |  | Paid or unpaid volunteers and interns, their contributions and/or consumption of programme resources | 9 |
| Students |  | Student contributions in terms of manpower and research | 7 |
| Externally provided workforce |  | External NGOs or citizen groups who volunteer for certain tasks | 6 |
| Staff willingness |  | Enthusiasm, willingness, interest and passion of staff | 3 |
| Automatization |  | Using automated technology to replace staff where possible | 1 |
|  |  |  |  |
| Management | Management of the programme and its relationships | | 22 |
| Category | Subcategory | Description |  |
| Leadership |  | The presence of one or more leaders who take on responsibility for parts or all of the programme | 13 |
|  | Change in management/leadership | Changes in management or leadership and how this affects the programme | 12 |
|  | Passion | Passion of leaders | 3 |
| Strategies and plans |  | Development and implementation of strategies and plans | 13 |
| Prioritization of species |  | Prioritization of species and how this influences the efficiency of programmes | 11 |
| Communication |  | Communicating the project to stakeholders | 9 |
| Staff management |  | Managing a content, productive workforce | 8 |
| Focus of the programme |  | Aspects which the programme decides to focus on, or not | 8 |
| Protocols |  | Husbandry, captive breeding and biosecurity protocols or guidelines | 8 |
| Mindsets |  | Ability of staff, managers and external partners to think openly, creatively, innovatively, and to consider "the bigger picture" of the programme | 8 |
| Facilitation |  | Facilitating and coordinating cooperation between stakeholders and partners | 6 |
| Responsibility |  | An institution or individual's sense of responsibility to contribute to conservation and to succeed with species they have already taken on | 6 |
| Balancing tasks |  | Prioritising tasks and allocating time in a productive manner | 3 |
| Managing expectations |  | Managing stakeholders' expectations of the programme | 2 |
| Network |  | Mentioned under support |  |
|  |  |  |  |
| Support | External and internal support (the latter is mainly relevant to programmes nested in bigger institutions) | | 22 |
| Category | Subcategory | Description |  |
| Internal support |  | A parent institution's perceptions and willingness to host and support the CBP, often within mixed collections | 13 |
| Problems in partnerships |  | Any issues regarding partnerships | 10 |
| Developing partnerships |  | Developing meaningful partners to the programme | 9 |
| Bureaucracy |  | Bureaucracy of governments or other partner institutions | 8 |
| Network |  | Availability of a wider network | 8 |
| Prioritization of amphibians |  | The prioritization of amphibians within institutions and by the public in relation to other taxa | 8 |
| Changes in support |  | Changes in support for programmes, for example due to changes in management or progress of a programme | 7 |
| All talk, no action |  | The notion of partners and governments which appear to support the programme, but practically don't | 5 |
| Inspiration/motivation |  | External inspiration or motivation which leads to initiation of the programme or keeps the programme leaders going | 3 |
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| Expertise | Internal and external skills, experience and knowledge | | 22 |
| Category | Subcategory | Description |  |
| Amphibian husbandry expertise |  | Available expertise for development of husbandry and breeding protocols (including that of staff and managers) | 18 |
| Veterinary expertise and laboratory expertise |  | Available veterinarian expertise, level of specialization in amphibians and expertise on using laboratory equipment. The impact of this on establishing causes of diseases | 13 |
| In-country capacity |  | Available capacity and expertise in-country to secure long-term running of the programme and other amphibian conservation activities in-country | 11 |
| Workshops |  | Workshops providing expertise, insight, information and training on specific species and their prioritization | 6 |
| Analogous species |  | The use of common analogous species to expert the skills needed to breed the rarer target species | 5 |
| Reintroduction expertise |  | Expertise on when and how to reintroduce species into the wild | 4 |
| Language skills |  | Ability to read and speak useful languages, mainly referring to English | 3 |
| Decision making expertise |  | Expertise on decision making | 3 |
| Outreach expertise |  | Expertise on outreach, education and publicity | 2 |
| Staff expertise |  | Mentioned under staff |  |
|  |  |  |  |
| In-situ conservation | Links to fieldwork and in-situ conservation | | 22 |
| Category | Subcategory | Description |  |
| Wild habitat conditions |  | Conditions of habitat in which the species lives or is to be introduced, and the mitigation of threats | 19 |
|  | Protection | Formal or informal protection of the habitats in which the species lives or is to be introduced, and/or protection of the species | 13 |
|  | Management | Management and restoration of unsuitable habitat, including water quality and clearing of invasive species | 12 |
|  | Available release sites | Identifying and evaluating suitability of, if any, available release sites | 9 |
| Access to field sites |  | Proximity and ease of access to field sites, influenced by weather, transport, political situation and land ownership | 8 |
| Allocation of resources for in situ conservation |  | Allocation of resources needed to carry out fieldwork by management | 8 |
|  | Allocation of time for fieldwork | Allocation of time within the institution/programme for fieldwork | 5 |
|  | Allocation of funds for fieldwork | Allocation of funding within the institution/programme for fieldwork | 2 |
| Fear/apprehension of introductions |  | Apprehension towards potential negative impacts of reintroductions and its impact on decision making of programmes or relevant authorities | 5 |
| Expertise on reintroductions |  | Mentioned under expertise |  |
| Outreach |  | Mentioned under social relations |  |
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| Species and individuals | Relating to the traits and health of the species or individuals | | 20 |
| Category | Subcategory | Description |  |
| Availability of founding individuals |  | Availability, at any point of the process, of founding individuals for the captive population | 10 |
| Diseases |  | Fungal infections, deformities or other diseases, and the lack of their identification due to lack of expertise such as amphibian specialist veterinarians | 8 |
| Genetic diversity |  | The maintenance of genetic diversity for captive and wild populations | 7 |
| Difficulty of species |  | The level of difficulty of understanding and recreating wild conditions in the captive environment of a species | 6 |
| Assurance population |  | The idea of a population functioning as an assurance population when wild threats cannot be mitigated, or wild populations are not in need of reintroductions | 5 |
| Other deaths |  | Other deaths can occur from failures in environmental control, poor water quality or nutrition and the lack of their identification due to lack of information or expertise | 5 |
| Ethics |  | Ethical considerations | 4 |
| Animal welfare |  | Standard of welfare for captive individuals | 3 |
| Taxonomic issues |  | Issues regarding the taxonomy of certain species, or genetic differences between wild populations | 3 |
| Ant infestations |  | Loss of specimens to ant infestations | 3 |
|  |  |  |  |
| Finance | Financial conditions | | 20 |
| Category | Subcategory | Description |  |
| Availability of financial resources |  | Available sources of financial resources to pursue | 14 |
| Fundraising/donors |  | Activities and external partners which contribute to raising funds for the programme | 13 |
| Continuity |  | Security of a continuous, long-term source of funding | 12 |
| Grants |  | Availability of grants and their contributions towards different aspects such as education, staff salaries or fieldwork | 11 |
| "Making do", financial discipline |  | Sufficiency of creatively and carefully used resources, making do with what is available | 9 |
| Biodiversity offsetting/corporate responsibility |  | Some companies fund programmes either directly or indirectly by providing field access and other resources | 3 |
| Allocation of funding internally |  | The internal allocation of funding for amphibian CBPs in mixed institutions | 3 |
| Biocommerce |  | The sale of specimens to raise funds for the programme | 1 |
|  |  |  |  |
| Other | Categories that do not fit in elsewhere, but relate directly or indirectly to the research question | | 20 |
| Category | Subcategory | Description |  |
| Next stage |  | Expression of an inability to push the programme towards further aims and objectives, independent of its ability to continue at the current stage | 11 |
| Political and socio-economic situation |  | The impact of the political, social and economic situation of the country or area in which the programme operates | 11 |
| Starting point |  | Description of the resources available to a programme when it started | 9 |
|  |  |  |  |
| Information | Wild and captive information of the species in the programme | | 17 |
| Category | Subcategory | Description |  |
| Availability of information |  | Availability of and access to pre-existing information on the species, or similar species, from in situ and ex situ studies | 11 |
| Species-specific information |  | Information on the species' conditions in nature and how to recreate the wild environment in captivity | 10 |
|  | Information on wild environments | Information on the environmental parameter of the species in the wild, used to recreate this environment in captivity | 4 |
|  | Information on nutrition | Information on nutritional requirements of the species and for amphibians in general | 4 |
|  | Information on wild behaviour | Information on behaviour, social systems and breeding, and on how to recreate this in captivity | 2 |
| Building information |  | Production of information by the programme | 6 |