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Review Article

Comparison of Different Trapping Techniques used in Herpetofaunal Monitoring: A Review

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WA wrote the article. AJ analyzed the data. SMB interpreted the tabular data. AH assisted in refining the document. SMH helped in formatting the manuscript. HR helped in drawing.

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Abstract | Herpetofaunal surveys are useful to record data related to diversity, distribution and habitat preferences of amphibians and reptiles in any particular ecosystem. During past few years, a decline in amphibian and reptilian species attracted attention of the conservation biologists worldwide to monitor herpetofunal diversity for effective conservation planning and management. Different sampling techniques are applied during herpetofaunal surveys and some of them might be expensive, time intensive and their effectiveness in different regions of the world are still debatable. Moreover, data recorded from inappropriate designed surveys are not suitable for statistical analysis and provide inappropriate picture regarding distribution, abundance and status of target species. Current review inspects different sampling techniques, various issues related to surveys design, application and ethical issues connected with these sampling techniques. It can be concluded from the literature survey that all sampling techniques have biasness related to geographical position, habitat and species under consideration. Pitfall traps are more effective for collection of ground dweller amphibians and reptiles having less jumping and climbing ability. Whereas, highly mobile species are captured through destructive means that cause disturbance to natural habitat. Cover boards are most likely to be used for long term surveys of amphibians. Furthermore, not even a single sampling technique can record all possible species in particular area. Researchers need to identify aims of survey and possible negative effects of sampling methods used on habitat and taxa under consideration. In addition, study area must be sub-divided into small patches and more than two suitable sampling techniques should be used to record all possible species.

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Introduction

Diversity and distribution of amphibians and reptiles is related with the climatic conditions and geographical position of any country. Amphibians and reptiles are important bio-indicators of moisture present in the environment and their population is depleting day by day due to many anthropogenic activities (Petrov, 2004). Although, these taxa are distributed throughout the globe; however, they are more diverse in tropics, sub-tropics and warm temperate areas. Regardless of their richness in many ecosystems, it is very difficult to quantitatively assess population of these environmental friendly creatures. Several factors including cryptic nature of herptiles, camouflage, climatic factors, activity patterns and hibernation make their capture difficult (Conant and Collins, 1998; Zug *et al.*, 2001). Many active and passive techniques have been developed to increase the number of captured individuals, which will aid in population estimation. Use of drift fences, pitfall and funnel traps are most common methods for the assessment of amphibians and reptiles. However, these traps have many

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pros and cons as one negative aspect of using drift fences is that they are time consuming and their inappropriate applications leads to low capturing and high mortality of captured individuals (Gibbons and Semlitsch, 1982). It is difficult to estimate the populations of amphibians and reptiles in a given area as some species are rare, nocturnal or inactive during most part of the year (Dodd, 1991).

During past few years, worldwide decline in amphibians and reptiles has attracted interest of the scientific community. About 28% (470 out of 1678) reptiles and 30% (1895 out of 6285) amphibians of the world are threatened. Comparing relative effectiveness, advantages, disadvantages and sampling biasness of these techniques is need of time to assess herpetofuana populations throughout the world (Franco *et al*., 2002).

Despite the availability of manuals and studies related to effectiveness of various traps, there is problem in application, understanding and biasness of these trapping techniques (Vanzolini and Papavero, 1967; Heyer *et al*., 1994; Rice *et al*., 1994; Crosswhite *et al*., 1999; Enge, 2001; Ryan *et al*., 2002). Rice *et al*. (2006) reported that not a single trapping method or material used in trapping is universal; several factors such as species, area, habitat and activity pattern of amphibians and reptiles greatly affect use of trapping techniques.

Survey Design

There are many sampling techniques used to sample herpetiles. Each sampling method has its own advantages and disadvantages based on life history and behavior of the target species (Table I).

Active Techniques

Visual encounter or active searches

Historically, amphibians and reptiles have been assessing through active search technique in the ecosystem where herpetologist expected them to be found. Vanzolini and Papavero (1967) and Corn and Bury (1990) advocated surveys under fallen trees, stones, leaf litter and at the edges of different water bodies. But this technique is biased as based on researcher's ability and specific species found in that particular habitat and does not provide exact estimation of abundance (Schmidt, 2003). Sobrevila and Bath (1992) recommended active sampling along 1 kilometer transect line as it provides most efficient and reliable data on amphibian and reptiles species richness and abundance. But several studies showed long term active searches are necessary to record maximum number species within given area or ecosystem. Greenberg *et al*. (1994) and Enge (1997a) reported that active surveys are effective for arboreal and highly mobile species as their ability to escape from pitfall and other passive traps.

Cover Boards

Cover boards mainly consist of wood or metal that attracts amphibians helping herpetologists to capture them without disturbing natural cover *viz*. logs, rocks and vegetation. The material and type of cover board mainly depends upon species, habitat and area under consideration. Wood cover boards are extensively used to sample woodland salamander species (Degraaf and Yamasaki, 1992; Fellers and Drost, 1994; Houze and Chandler, 2002; Moore, 2005; Luhring and Young, 2006). Marsh and Goicochea (2003) reported that main constraint in using cover boards is that animals start to avoid if they are extensively used.

Passive Techniques/Traps

Use of passive traps to sample amphibians and reptiles is time and effort intensive technique; however, it is better method as compared to opportunistic or visual searches and mostly used to capture rare species having conservation importance.

Table I: Advantages and disadvantages of different sampling techniques used to monitor herpetofauna.

Sampling techniques	Target species	Advantages	Disadvantages
Dry pitfall traps	Ground dwellers that have less jumping and climbing ability	Less harmful to animals and captures animals that doesn't produce calls	Capture rates is less and expensive
Wet pitfall traps	Ground dwellers	Less labor required and capture rate is high as compare to dry pitfalls	Kill large number of animals
Funnel traps	Ground dwellers	Less time intensive during installation that pitfall traps	Death rate is high due to desiccation
Active searches	Highly active or mobile species	Less destruction to habitat and cheap	Animals can easily conceal themselves
Cover boards	Amphibians *viz*., Salamanders, frogs and toad	Less destructive and useful for long term surveys	Expensive and not suitable for short term surveys
Counting and recording sounds calls	Amphibian species produce prolonged sound calls during breeding season	Detects animals that cannot be easily seen and produce calls	Cannot capture animals that doesn't produce sound calls
Destructive searches	Highly active or mobile species	Capture rate is high	Destroy habitat

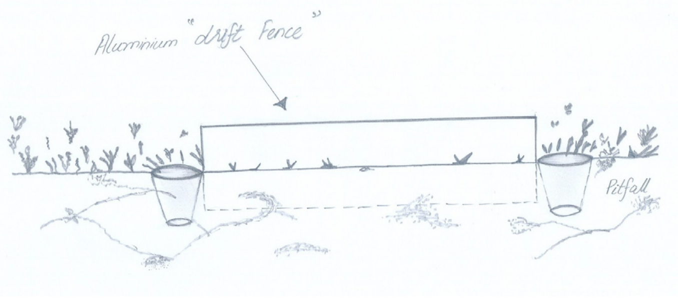

Figure 1: Drift fences with pitfall traps (Andrews *et al*., 1994).

Drift fences

Drift fences (Figure 1) are the vertical barriers that intercept the movement of herpetofauna and lead them towards installed pitfall and funnel traps to increase capturing rates (Corn, 1994). Success of this technique is greatly influenced by climatic conditions, season and activity of amphibians and reptiles (Greenberg *et al*., 1994; Jorgensen *et al*., 1998; Enge, 2005; Todd *et al*., 2007). Drift fences have been effectively used in USA to sample amphibians and reptiles but are ineffective for forests of Queensland, Australia (Gittins, 1983; Friend, 1984; Bury and Corn, 1987; Friend *et al*., 1989; Jehle *et al*., 1995; Parris *et al*., 1999; Weddeling *et al*., 2004).

Some advantages of drift fences include effective assessment of diurnal and nocturnal species, capturing of surface active and cryptic species, sampling from aquatic and terrestrial ecosystems, time efficient, consist of durable materials and allow permanent trapping locations. However, there are certain disadvantages of drift fences as they are take much time in installation, are expensive, mortality rate is high due to overheating, desiccation, drowning and predation, unable to capture large turtles, snakes and arboreal herpetile species while some time drift fences are highly visible.

Material used in drift fences

Drift fences can also be installed along natural barriers and mostly constructed with aluminum flashing, metal sheet, window screen, plastic screen, hardware cloth, wires, green sheet, polyethylene and silt fencing (Dodd, 1995).

Pitfall traps

Pit fall traps can be metal or plastic cans to drums but should be deep enough to prevent escape of the target species (Figure 2A, B). These traps are the efficient way of capturing smaller, fossorial and semi arboreal species of amphibian and reptiles such as members of Bufonids, Ranids and for salamanders if pit fall traps installed near water bodies (Gibbons and Semlitsch, 1981). The captured animals have threats against predators in pit fall traps but if they were established with anti-predator devices it will reduce risk of predation without effecting capture rate (Ferguson and Forstner, 2006). Moreover, pitfall traps that are installed with a flip cover to assess turtles' species ultimately affect capturing of other species (Christiansen and Vandewalle, 2000). Rates of capture of target animals also can be skewed where alterations are made to prevent mortality of non-target animals (Karraker, 2001). Maritz *et al*. (2006) reported that rate of capture directly influenced by size of pitfall traps and combination with other traps. Greenberg *et al*. (1994) reported that pit fall traps captured less species but more individuals and mostly lizards, frogs and small semi-fossorial species are captured. Thompson *et al*. (2005) reported that PVC pipes and buckets used as pit fall traps have sample biased as it is helpful to capture small to medium sized herptiles and large snakes and varanids. However, it has been observed that many geckos' species especially are able to escape from PVC buckets and pipes hence these taxa remained under sampled. Jorgensen *et al*. (1998) reported biasness of pit fall traps as whiptail skink (*Cnemidophorus marmoratus*) capture rate was more than *Uta stansburiana*.

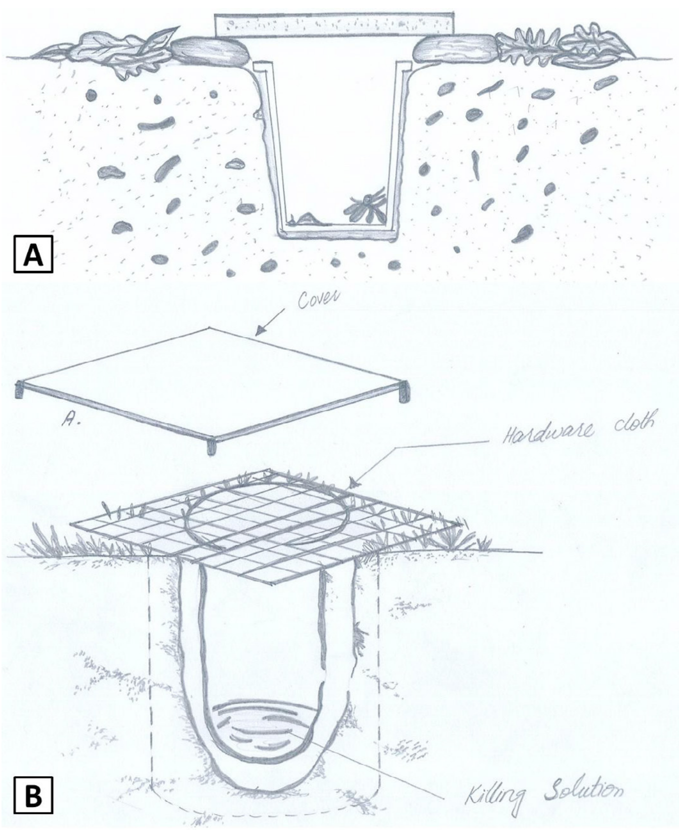

Figure 2: Pitfall trap (A) and pitfall trap with cover board (B) (Raxworthy and Nussbaum, 1994).

Problems with pitfall traps

Ferguson *et al*. (2008) reported major problem with pitfall traps as other larger vertebrates foraging on specimens captured in pit fall traps by using cameras and track-monitoring stations in Bastrop and Guadalupe counties, Texas. During study period 316 photographs were taken using 327 cameras at 50 pitfall traps with associated with drift-fence arrays and recorded 679 specimens. *Procyon lotor* was most common species visiting pitfalls out

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of 10 recorded vertebrate predators. Furthermore, statistical analysis showed that predators did not affect the capturing of herpetofaunal species but play vital role in less number of individuals will be captured. Regular visiting of predators to pitfalls traps has negatively affect the rare or endangered species at higher levels.

Funnel traps

Funnel traps are mostly funnel shaped that leads the animals towards larger holding tanks (Figure 3A, B). Funnel traps were first used by Imler (1945) to control bull snakes (*Pituophis sayi*) and since then funnel traps had been used to capture various aquatic and arboreal species of amphibian and reptiles (Vogt, 1987; Casazza and Wylie, 2000). Mostly funnel traps have been used in USA as compare to Australia (Greenberg *et al*., 1994; Jorgensen *et al*., 1998; Crosswhite *et al*., 1999; Enge, 2001). Funnel traps are less time intensive during their installation and capture wide range of animals by ensuring their safety against predator. More often funnel traps are installed with pitfall traps when complete assessment of herpeto faunal diversity is required in most of regions (Dargan and Stickel, 1949). Enge (2001) reported that funnel traps are less effective for fossorial and semi fossorial lizards and several studies reported that funnel traps are more effective to capture several snake species (Campbell and Christman, 1982; Gibbons and Semlitsch, 1982; Vogt and Hine, 1982; Bury and Corn, 1987).

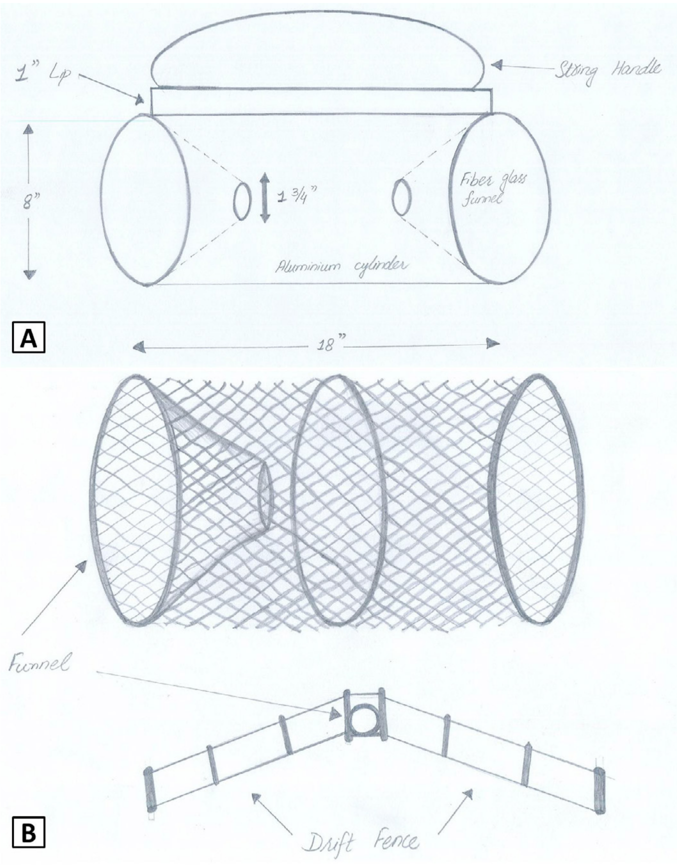

Figure 3: Funnel trap (A) and funnel trap with drift fences (B) (Beauregard and Leclair, 1988).

Funnel traps *viz*. cylindrical wire, plastic minnow traps, collapsible rectangular traps and plastic soda bottles traps are effective way to capture amphibians and their tadpoles in aquatic ecosystems (Heyer *et al*., 1994; Olson *et al*., 1997; Adams *et al*., 1997; Willson and Dorcas, 2003). Funnel traps also build using PVC pipes to capture tree frogs success is influenced by size classes, pipe design, location and several studies reported that tree frog used PVC pipe funnel traps as artificial refugia (Moulton, 1996; Boughton *et al*., 2000). Jorgensen *et al*. (1998) observed that dragon lizards and many species of arboreal geckos successfully trapped in funnel traps as they have ability to escape from pit fall traps.

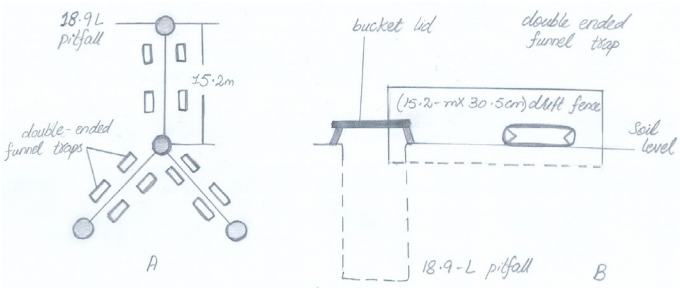

Figure 4: Survey design for sampling amphibian and reptiles (Rice *et al*., 2006).

History of using Different Traps

A list of studies carried out to assess the amphibians in different part of the globe is given in Table II. Antonio and Eterovick (2013) conducted herpteo faunal assessment in Inhotim Institute in Southeastern Brazil by using pitfall traps with drift fences, visual and auditory surveys and direct capturing with bare hands. Out of 65 captured species 32 amphibians and 33 reptiles were recorded. All the techniques were equally effective and more herpetiles were captured during human habitations as most of the species had generalist habitat preferences (Figure 4). Cathryn *et al*. (1994) conducted a survey to check the relative effectiveness of pit fall traps, single ended and double ended funnel traps in addition with drift fencesat 12 replicate study sites during 1994. The obtained data revealed that pitfall traps captured less species but trapped more specimens as compare to funnel traps. Both trapping methods showed species biasness based on species morphology and activity pattern. Funnel traps were effective way to capture snakes as double-ended funnel traps captured more of large snake but pit fall traps captured lizards, frogs and semi arboreal species of herpetiles. Relative abundance of all the three traps were high for lizards, frog, toads but not for snakes.

Crosswhite *et al*. (1999) conducted a survey in upland forests of the Ouachita Mountains, Arkansasto compare the effectiveness of time constrained searching, drift fence arrays with pit fall traps and double ended funnel traps

Table II: A list of surveys carried out to sample amphibian's in different continents of the world.

Authors	Locality	Species	Sampling techniques
RaxworthyandNussbaum, 1994	Madagascar	Frogs	Active searches and Pitfalls
IngerandColwell, 1977	Thailand	Frogs and toads	Diurnal and nocturnal active searches
IngerandVoris, 1993	Borneo	Stream breeding frogs	Nocturnal active searches at streams
Inger *et al*., 1987	Southern India	Frogs and toads	Diurnal and nocturnal active searches
Andrews *et al*.,1994	Northern Australia	Frogs	Diurnal and nocturnal active searches and pitfall traps
Driscoll, 1998	Southwestern Australia	Orange-bellied Frog (*Geocriniavitellina*)	Counting and recording sounds calls
Friend and Cellier, 1990	Northern Australia	Frogs	Diurnal and nocturnal active searches and pitfall traps
Gillespie and Hollis, 1996	South-east Australia	Spencer's river tree frog (*Litoriaspenceri*)	Active stream searches
Goldingay *et al*., 1996	Southern Australia	Frogs	Diurnal and nocturnal active searches
Hollis, 1995	Victoria, Australia	Baw Baw frog (*Philoriafrosti*)	Counting and recording sounds callsand active searches for eggs
Lemckert, 1995	Northern Australia	Frogs	Nocturnal active searches
Mahoney, 1993	Central Wales, Australia	Frogs	Nocturnal active searches
McDonald, 1990	Queensland, Australia	Platypus frogs (*Rheobatrachusvitellinus*)	Diurnal and nocturnal active searches at streams
Osborne, 1989	Mountains of South Wales, Australia	Corroboree frog (*Pseudophryne corroboree*)	Diurnal counting sounds calls and active tadpole sampling
Richards *et al*., 1993	Queensland, Australia	Streams breeding frogs	Diurnal and nocturnal active searches and netting for tadpoles
Torr, 1993	Queensland, Australia	Frogs	Diurnal active searches and pitfalls
Woinarski and Gambold, 1992	Northern Australia	Frogs	Diurnal active searches and pitfalls
Brana *et al*., 1996	Northern part of Spain	Lake breeding frogs and toads	Diurnal active searches and tadpole sampling through nets
Sjogren, 1994	Sweden	Pool frog(*Ranalessonae*)	Diurnal and nocturnal active searches
Stumpel and van der Hoet, 1998	Netherlands	Pond breeding frogs and toads	Diurnal active searches and tadpole sampling through nets
Aubry *et al*., 1988	Washington, USA	Frogs and toads	Diurnal active searches in forest
Beauregard and Leclair, 1988	Canada	Frogs	Funnel traps
Bury and Corn, 1988	Washington, USA	Frogs and toads	Diurnal active searches and pitfalls
Collins *et al*., 1988	Arizona, USA	Tiger salamander (*Ambystomatigrinum*)	Diurnal active searches and use of nets
Dalrymple, 1988	Florida, USA	Frogs and toads	Diurnal and nocturnal active searches and use of funnel traps
Hecnar and M'Closkey, 1997	Ontario, Canada	Pond breeding Frogs and toads	Diurnal active searches and netting for tadpoles sampling
Jones, 1988	Arizona, USA	Frogs and toads	Pitfall traps and nocturnal active searches
Petranka *et al*., 1994	Carolina, USA	Salamanders	Diurnal active searches
Ramotnik and Scott, 1988	Mexico, USA	Jemez Mountains Salamander (*Plethodonneomexicanus*) and Sacramento Mountain salamander (*Aneideshardii*)	Diurnal active searches
Saugey *et al*., 1988	Arkansas, USA	Cave dwelling salamanders	Active searches in caves and mines
Welsh and Lind, 1995	California, USA	Del nortesalamander (*Plethodon elongates*)	Diurnal active searches
Aichinger, 1987	Peru	Stream and pond breeding amphibians	Diurnal and nocturnal active searches
Crump *et al*., 1992	Costa Rica	Golden toad (*Bufoperiglenes*)	Diurnal active searches
Gascon, 1991	Brazil	Aquatic frogs	Active searches
Lips, 1998	Puntarenas, Costa Rica	Frogs and toads	Nocturnal and diurnal active searches at streams

without drift fences to assess population of amphibian and reptiles. The result of 91 trapping days yielded 886 specimens representing 38 species of herpetiles. The data showed that time constrained searching are the efficient way of monitoring herpetofunal followed by drift fence arrays and then funnel traps. Pitfalls were effective of capturing amphibian, salamanders, lizards and small snakes whereas double-ended funnel traps captured large lizards and snakes. The material used in traps also effect catching rate as aluminum window screen used in funnel traps is better for catching small lizards and snakes than hardware cloth as small individuals escape through larger mesh size. Rolfe *et al.* (2000) used a combination of pit fall traps and hand capturing methods to assess amphibian and reptile species at 63 quadrats in the southern Carnarvon Basin of Western Australia during 2000. Three types of pit falls used *viz*., fenced tubes having 125 mm diameter and 550 mm depth, fenced buckets with 300 mm diameter and 450 mm depth and unfenced pits having 300 mm diameter and 450 mm depth. The buckets contributed only 0.12% of captured species as compare to active sampling.

Jarrod *et al.* (2003) used area searches and pitfall traps to monitor amphibian and reptiles species at public lands in east central Mississippi. Area searches were conducted along 300 square meter belt using transects measuring at distances of 0, 25, 50, 75 and 100 m from the first and second order streams. Pitfalls were installed along transects at the distance of 0, 50 and 100 m. Transects were surveyed 2 to 3 times per during 84 surveys over 21 study sites. A total of 615 specimens of amphibians representing 17 species while 741 specimens of reptiles representing 24 species were captured during transect surveys. Pitfall traps yielded 315 specimens of amphibian representing 10 species whereas 135 individuals of reptiles belonging to 9 species. The result reveled that both methods together are effective way of herpetofaunal assessment. Ribeiro-Junior *et al.* (2008) conducted a study to check the relative effectiveness of different sampling techniques in tropical forests. However, the study was biased by methods, species and geographic region. The result revealed that use of pitfall traps in all studies, even in rapid assessments (RAP) as they capture many cryptic species and cost effective for long term research.

Tietje *et al.* (1997) conducted a comprehensive study in prescribed burning oak woodland, California. Active and passive methods were used such as time and area constrained searches and pit fall traps respectively. Cover boards were monitored every 7 to10 days from February through April during 1995 through 1996 and recorded 2658 specimens' representing17 species of amphibians, lizards and snakes. Different sampling techniques capture snakes species in following order cover boards>active searches >pit fall traps. Cover boards have less cost of materials, maintenance, operation time, risk of injury to animals and recommended in oak woodlands to record amphibian and reptile species. Boughton *et al.* (2000) used different design and placement of PVC pipes as refugia to capture tree frogs in north-central Florida during 2000. Pipes were checked twice in week and recorded 788 specimens belonging to four species *viz*., *Hylasquirella, H. cinerea, H. femoralis and H. gratiosa.*

Graham *et al.* (2007) used funnel traps with pit fall traps and cage traps at 10 sites in southern Western Australia to check sampling biasness of traps. Funnel traps captured medium and large diurnal snakes, skinks, medium sized dragon lizards and arboreal geckos. The data showed that funnel traps, pitfall traps and cage traps should be used in surveys of small terrestrial vertebrates to determine species richness and relative abundance in Western Australia. Hobbs *et al.* (1994) used eight pit fall traps designs to compare the effectiveness of design for herpetiles in arid grasslands of central Australia. Results from seven surveys showed that more complicated designs with cross fences are not suitable for trapping amphibian and reptiles and did not increase catch rate. Furthermore, a simple straight line of pitfalls and drift fence at 7 meter apart is more effective design and recommended for sampling herptiles in arid Australia.

Todd *et al.* (2007) have evaluated drift fence efficiency with multiple traps such as large pitfall traps, small pitfall traps and funnel traps in isolated wetland in the southeastern United States in 2007. Funnel traps captured more herpetofaunal species than other traps but combination of funnel traps with large pitfall traps yielded maximum number of individuals. Small pitfall traps were relatively ineffective for sampling herpetofauna in study area. Drift fence monitoring affected the rate of herpetofauna capture and season affects the activity pattern and capture of specific taxa.

Webb (1999) reported the effectiveness pitfalls designs and pitfall traps with drift fence systems for sampling lizards and frogs in the forests of southeastern Australia in 1999. Drift fence with pitfall traps were most efficient that no fence system in terms of number of specimens of Space different species caught. The only drawback with this technique is that they are time consuming and caused serious habitat disturbance. It is recommended to use open necked pitfall traps with short fence systems in forested area and should avoid complex traps and long drift fence system.

Davis *et al.* (2008) have conducted a study to capture small arboreal reptiles which can be difficult to capture except in traps. These reptiles some time examined bait, attractiveness of different visual and acoustic cues and efficacy of different drift fence materials. The result of experiment showed that lizards arboreal preferred crickets as bait and avoid darkness and cover. The results of the study recommend use of crickets as bait and drift fences constructed from flashing material can increase sampling success in lizards.

Ribeiro-Júnior *et al.* (2008) have used glue traps to evaluate how capture success can be influenced by trap placement for sampling lizard in rain forest and neo-tropical forest in Brazil. Traps were placed at tree trunks, fallen logs and lianas. 244 specimens were recorded representing 12 species. More than 80% of specimens of *Gonatodes humeralis* and *Anolis fuscoauratus* were captured. Traps placed on fallen logs recorded more individuals and a higher capture success than traps set on treet runks or lianas. Furthermore, success of glue traps placed on tree trunks did not vary with height above the ground. The study found negative correlation between trap success and the number of trap days and indicate that glue trapping can provide a useful addition to other sampling methods in the study of neo-tropical forest lizards. Ribeiro-Júnior *et al.* (2011) used pitfall traps with drift fences to sample leaf litter amphibians, lizards and small mammals in a Neo-tropical forest. However, there are still many concerns over the effectiveness of traps and their design. During current study two trap designs viz., I and Y format and three bucket sizes i.e 35, 62 and 100 L were used. Results are very similar for the herpetofauna, regardless of the pitfalls design and size. Whereas small mammals had high species richness for 100 L pitfalls buckets. It is recommended 100 L pit fall traps should be used to sample mammals while 35 L pitfall traps is acceptable for herpetiles as cost benefits and success in multi displinary trapping. Farallo *et al.* (2010) investigated effectiveness of drift fences, single ended funnel traps and one way double funnel design. Five 15 meter linear drift-fence with three 15-m Y shaped arrays were installed at Seabrook Island, South Carolina. Each array contained an equal number of the single-funnel and double-funnel traps. The data revealed that double funnel traps have more success than single-funnel trap in monitoring amphibian and reptile's species in any part of the world.

Shipley *et al.* (2008), recorded 152 individuals of amphibian and reptiles representing 10 species using ground captures, pitfalls, single ended and double ended funnel traps with drift fences in black-tailed prairie dog (*Cynomys ludovicianus*) colonies and un-colonized areas in short grass prairie. The efficacy of funnel traps (52.6%) was more as compared to ground captures (24.3%) and pitfall trap (23.0%). Moreover, 51.3% of all herpetiles were captured from prairie dog colonies as compare to 48.7% from uncolonized areas. Funnel traps and pitfall traps more successful in uncolonized areas and ground capture was high in colonies. Ryan *et al.* (2002) conducted a survey in five types of habitat (bottomland wetlands, isolated upland wetlands, clear-cut, pine plantation and mixed pine hardwood forest) on a managed landscape to assess herpetofauna populations using three sampling techniques *viz.*, Pitfalls, drift fences and cover boards. All the sampling techniques used in terrestrial habitats were not equally effective in capturing while drift fence recorded more species and specimens in all the habitat types. Cover boards were more effective to check the abundance of herpetofaunal communities. The recommendations of the survey were to use combination of all sampling techniques in every types of habitat to monitoring herpetiles populations successfully.

Statistical Considerations

Data collected from surveys conducted at replicate sites are feasible for statistical analysis to find out of relationships between the herpetofauna, habitat, activity, climatic conditions and population trends (Pechmann *et al.*, 1991; Denton and Beebee, 1992; Petranka *et al.*, 1994; Welsh and Lind, 1995). Sampling areas should be far enough so that presence of one species is not affected by its presence or absence at another area. An inappropriate survey design, insufficient replicated sites will reduce the value of data obtained and limit statistical analysis to observe significant results (Sokal and Rohlf, 1981).

Ethics

Uses of sampling techniques such as wet pitfall traps and funnels traps that kill captured animals and disturb their habitat will ethical issues. Active searches during field surveys may result in disturbance and destruction of herpetofauna habitat that's why less or non-destructive sampling techniques are important to protect rare, endangered and integrity of species under study (Farnsworth and Rosovsky, 1993). Webb (1991) reported that wet pitfall traps that contain formalin or other preservatives kill all captured animals and cause mass mortality. Similarly, dry pitfall traps can also cause death to many animals due to desiccation, starvation and by predators (Halliday, 1996). Researchers need to justify the use of such destructive techniques used in their study to address certain ethical concerns.

Conclusion

Current review concludes that: 1) All trapping techniques have biasness to geographical position, habitat and species under consideration, 2) Snakes are more likely to capture with funnel traps than pitfall traps, 3) Pitfall traps are more effective for ground dwellers herptiles that have less jumping and climbing ability, 4) Cover boards are mostly likely to be used for long term surveys of amphibians' *viz.*, frogs, toads and salamanders, 5) Single trapping technique cannot record all possible species in particular area, 6) Most of the studies have evaluated either between active or passive techniques very few have been compare between both active and passive sampling and 7) Fewer studies are conducted on different sampling techniques used in tropical forest to monitor herpetofaunal diversity.

Recommendation

Planning herpetofaunal surveys are required to address some issues regarding effectiveness of different trapping techniques, including: 1) Researchers need to identify aims of survey and possible negative effects of sampling methods used on habitat and taxa under consideration, 2) Study area must be sub-divided into small patches and more than two suitable sampling techniques should be used for target taxa or species and 3) Thoroughly review available literature on study area and if not enough information is available researcher should use all sampling techniques at same time to ensure a valid comparison.

Conflicts of interest

The authors declare no conflicts of interest.

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