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*Ornithological Methods*

# Bye-bye bycatch: a remotely closing trap for targeted songbird capture

## Chau chau a la captura incidental: una trampa que se cierra remotamente para la captura selectiva de un ave cantora

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ABSTRACT. Capturing and marking animals is often an essential component of studying wild populations, but the process of capturing and marking can have detrimental effects on captured birds. For instance, research projects are often focused on one or a few species, yet many other, non-target species can be inadvertently captured. Bycatch (non-target animals that are captured during the process of capturing target animals) is a frequent problem in ornithological research projects using non-selective capture methods such as mist nets, Potter traps, or other passive, baited traps. These non-target individuals likely suffer negative welfare implications from being caught (with potential effects on their health and fitness), and researchers may waste valuable time and resources processing bycatch for release when they could be focusing on capturing and collecting data from target species. To remedy this problem, we introduce here a relatively simple trap design that installs on a bird feeder and traps birds using a wireless, remotely closing door to allow selective capture of birds visiting a feeding station, a common capturing context in ornithological studies. We describe how to construct the selective, remotely closing trap and report our experience using the traps to selectively capture House Sparrows (*Passer domesticus*) in comparison to mist nets. This easy-to-use trap will benefit researchers looking to effectively and efficiently capture target species while also decreasing bycatch and will be especially convenient at established bird feeding stations.

RESUMEN. Capturar y marcar animales es un componente esencial de estudiar poblaciones silvestres, pero el proceso de capturar y marcar puede tener efectos perjudiciales en las aves capturadas. Por ejemplo, los proyectos de investigación generalmente están enfocados en una o pocas especies, sin embargo muchas otras especies no-objetivo pueden ser capturadas inadvertidamente. La captura incidental (animales no-objetivo que son capturados durante el proceso de captura de animales objetivo) es un problema frecuente en proyectos de investigación ornitológica que usan métodos de captura no-selectivos, como por ejemplo redes de neblina, trampas con recipientes, u otras trampas pasivas con cebos. Estos individuos no-objetivo probablemente sufren implicancias negativas para su bienestar al ser capturadas (con efectos potenciales a su salud y aptitud física), y los investigadores pueden perder tiempo y recursos valiosos en procesar capturas incidentales para liberarlas, cuando podrían enfocarse en capturar y colectar datos de especies-objetivo. Para remediar este problema, aquí introducimos una trampa con diseño relativamente simple, que se instala en un comedero de aves y atrapa aves usando una puerta operada de forma inalámbrica y remota, para permitir una captura selectiva de las aves que visitan una estación de alimentación, el cual es un contexto de captura común en estudios ornitológicos. Describimos cómo construir la trampa selectiva que se cierra remotamente y reportamos nuestra experiencia usando las trampas para capturar selectivamente Gorriones Domésticos (*Passer domesticus*) en comparación con redes de neblina. Esta trampa fácil de usar beneficiará a investigadores que buscan capturar efectiva y eficientemente especies objetivo y al mismo tiempo reduciendo la captura incidental, y será especialmente conveniente en estaciones de alimentación establecidas.

Key Words: *animal welfare; bird feeding stations; mist nets; selective capture; songbirds*

## INTRODUCTION

Research on wild animal populations frequently requires the capture of individuals. Individual identification through banding, for example, has provided invaluable insight into the ranges, demographics, and behavior of wild bird populations (Smith 2013). A variety of techniques is available for capturing wild birds, including mist nests, baited traps, and net launchers. Capture techniques can, however, have detrimental impacts on individuals, including causing short- and long-term stress, injury, and even sometimes death (Angelier et al. 2010, Duarte 2013). In line with the 3Rs principle (Zemanova 2020), trapping refinements are crucial to reducing the magnitude and frequency of such negative impacts on birds.

Many songbirds, and even larger birds, are trapped at feeding stations by using either mist nets or traps surrounding feeders. A single species is often the focus of such efforts, yet many additional, non-target species, typically called bycatch, can unintentionally be captured in traps. Such bycatch is particularly likely to occur when using non-selective trapping techniques such as mist nets or baited Potter traps. Capture can have negative impacts on the welfare of the non-target individuals, for example inducing stress responses (Romero and Romero 2002), causing injury (Spotswood et al. 2012), and interrupting foraging (MacLeod and Gosler 2006). Additionally, bycatch can consume researchers' time and potentially decrease the ability to capture target individuals when, for example, target birds are repelled by researchers' presence at the mist net while disentangling non-targeted birds, or captured non-target birds produce alarm, distress, or aggressive calls. Selective trapping techniques, on the other hand, can provide researchers with more control over the capture frequency of non-target individuals or species, potentially eliminating bycatch. However, there are relatively few published designs of traps that use modern technology (e.g., electronics) to

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selectively capture target individuals. The only published trap designs we found that employ modern technology for targeted capture are designed specifically for nest boxes (Lombardo and Kemly 1983, Plice and Balgooyen 1999, Saunders and Shutler 2019, Nilsson and Watson 2025), a relatively narrow use case that is only applicable to cavity-nesting species. Furthermore, traditional selective traps for settings other than nest boxes (e.g., Bub 1978, Bateman 2003) are used far less frequently than passive capture methods such as mist nets, funnel traps, and Potter traps. The development and broader implementation of easy-to-use selective capture techniques can reduce the frequency of non-target captures, save researchers' time, and mitigate negative impacts that research activities have on the welfare of wild birds.

Here, to remedy the problem of bird bycatch, we introduce a new trap design using modern technology that allows researchers to selectively capture birds at feeding stations. Our design refines the commonly used funnel traps, wherein birds enter a trap and have difficulty locating the exit, by replacing the door of the trap with a remotely controlled sliding door. The remote closing of the door is achieved by using a car door locking mechanism to keep the trap open and a wireless key fob that allows gravity to close the door when triggered by the researcher. We demonstrate this trapping technique with House Sparrows (*Passer domesticus*). We provide instructional materials for building and using the trap, as well as an overview of the pros and cons of this trapping technique relative to using mist nets at feeding stations. Overall, this trap design provides researchers with an effective approach for selectively capturing birds at feeding stations, which can allow practitioners to better meet the objectives of their research while also decreasing the negative repercussions of research practices on birds' welfare.

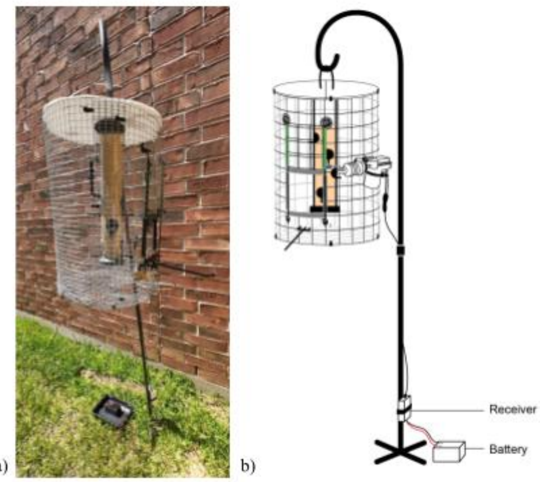
## METHODS

### Trap construction

In addition to this written description of trap construction, a video is available (https://www.wildanimalinitiative.org/blog/songbird-trap) for a detailed, visual explanation of constructing the trap. Appendix 1 contains detailed descriptions of materials and where they can be purchased.

We made the trap with the goal of having a hanging bird feeder in the approximate center of the trap, using only the feeder's hanging mechanism for support/suspending the trap (Fig. 1). We used galvanized steel hardware cloth (Everbilt 1/2 in. mesh x 3 ft. x 5 ft. 19-gauge galvanized steel hardware cloth) to first create a tube approximately 36 cm in diameter and 43 cm tall, using zip ties to hold the mesh in shape. The trap was tall enough to fit the entire length of the feeder, including the hanger, inside, and wide enough to allow about 18 cm of space between the feeder and wall of the tube. We closed off one end of the tube with more hardware cloth, affixing it with zip ties, to create the bottom of the trap. Throughout, we used metal snips and nippers to cut the hardware cloth, cutting each wire as close as possible to the wire perpendicular to it so that wires would not injure researchers or birds. If wires could not be cut close enough, we filed or sanded them down, or folded electrical or duct tape over sharp ends, being careful not to leave any adhesive exposed where feathers, debris, or small animals might get stuck.

**Fig. 1.** (a) Photo of the remotely closing trap fully set up with a tube feeder in the center. (b) Labeled diagram of the remotely closing trap set up with a tube feeder in the center. Diagram credit: Jacie Woznicki.




To create the top of the trap, we cut a corrugated twinwall plastic sheet (Coroplast polypropylene COR-2418, 24 x 18, 4 mm) into a circle with the same diameter as the tube (we traced the open top of the tube onto the plastic sheet as a cutting guide). At approximately the center of the sheet, we cut out a small rectangle parallel to the corrugations that would allow only the hanger of the bird feeder to slide through. A few centimeters away from this cutout, we cut one wall of the plastic sheet parallel to and between two corrugations so that the circle would easily fold there to create a flap that could open. This allowed for the feeder to be lowered in and raised out of the trap. Importantly, the flap of the plastic sheet circle needed to be able to open outward from the trap (to achieve this, the wall with the cut in it faced into the trap). We cut about four small slots near the edges of the plastic circle to affix the plastic sheet to the top of the trap with zip ties. We did not affix the flap so that we could insert and remove the feeder from the trap (Fig. 2a). Only when ready to capture did we fix the flap closed with a twist tie, so that we could readily reopen it to remove the feeder after trapping was complete.

Once the frame was complete, we cut openings in the trap to act as doorways for birds (keeping the cutouts for later use). We created two doorways so that birds would be able to learn how to get in and out more quickly during an initial habituation phase, even though a single doorway would be used for capture (after the habituation period, we closed off the secondary doorway by placing the cutout back into the doorway and attaching it with twist ties). We made the doorway large enough for the target species to fit comfortably through (ca. 10 x 12 cm for small songbirds). The doorway with the remotely closing mechanism needed to be low enough on the trap to allow the door to be raised above it; thus for a 12 cm-tall door, the doorway was at least 16 cm below the top of the trap (Fig. 3). To make sure the edges of the doorway were not sharp, we tried two techniques. We folded electrical or duct tape over the edges. Alternatively, to have more

**Fig. 2.** Photos of details of the remotely closing trap. (a) A corrugated twinwall plastic sheet was attached to the top of the trap with zip ties. The bottom wall of the plastic sheet was sliced to create a flap that allowed a bird feeder to be lowered in and raised out of the trap. A small rectangle was cut out to allow the feeder hanger to be passed through the plastic sheet to suspend the feeder/trap combination from a shepherd's hook. (b) Close-up of connecting rod and forked wire connector holding the door in the open position.

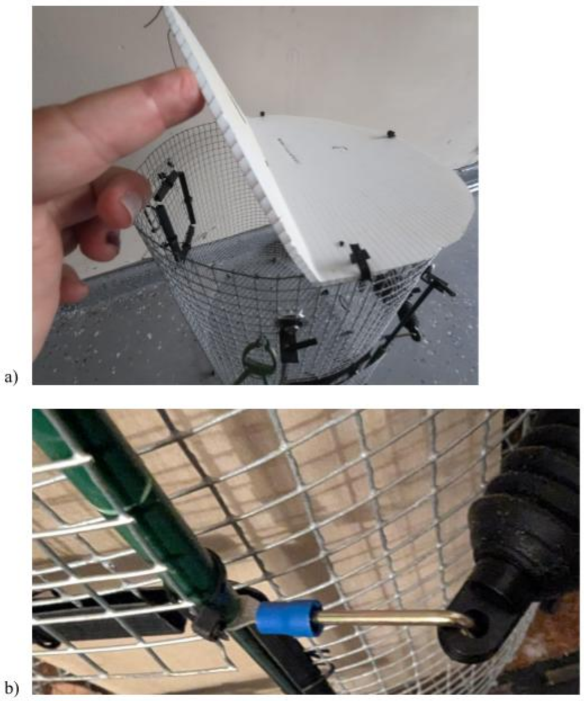
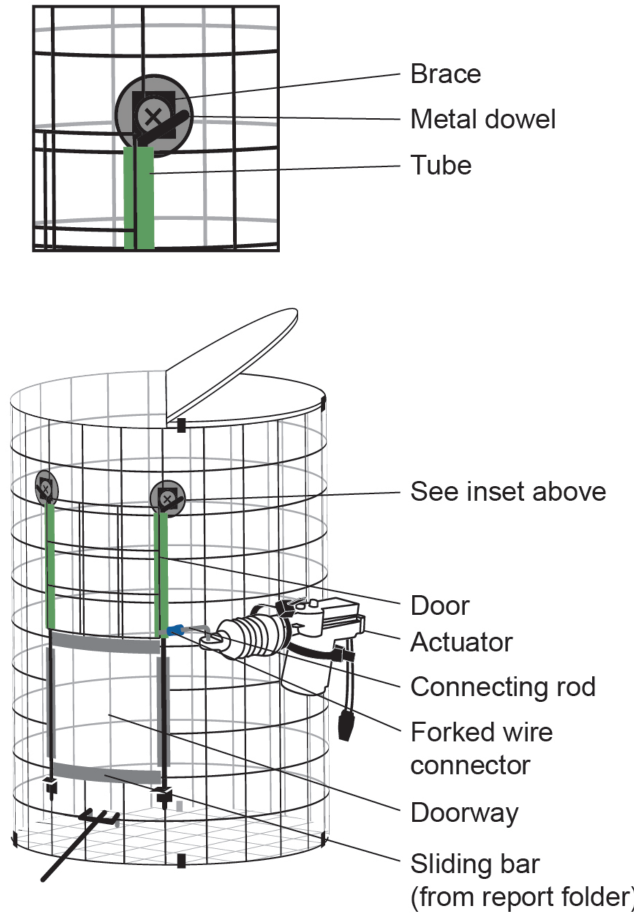



**Fig. 3.** Labeled diagram of the remotely closing trap, focusing on the door and closing mechanism. Diagram credit: Jacie Woznicki.




robust protection, we used the bar of a sliding bar report cover (COIDEA 13-pack Report Covers with Sliding Bars), cut to the correct lengths for each side of the doorway, and secured them with a twist tie. We also affixed a perch on the outside of the trap just below the doors to give birds a place to land and observe the trap before entering. Many long, thin, metal materials sufficed as a perch (see Appendix 1 for suggestions).

### Door and closing mechanism

We created a door mechanism that would close using a car remote door lock. We designed the door to close under its own weight once released. We used the cutout created when cutting open the doorway as the door. To provide a way for the door to slide, we twist-tied the two vertical edges of the door to a thin tube cut to the same height (Fig. 3). Many types of small diameter tubes would work, but we used hollow fiberglass plant stick supports (MAXPACE 62pcs Garden Stakes Kit; 8.5 mm in diameter), cutting them to the correct length with a hacksaw. We found that to slide freely, the door needed to be rather loosely attached to the tubes.

We attached two metal dowels vertically on the trap, one on each side of the doorway, to act as tracks on which the door could slide. These dowels needed to be greater than twice the height of the door, so that the door could slide up to leave the doorway open and slide down to cover the full doorway. We attached the dowels to the trap using four small, single-hole L-shaped corner braces (Everbilt ¾ in. Black Corner Brace, 4-pack), ensuring that the size of the holes in the braces were larger than the diameter of the dowels. Each brace was attached to the trap by using a bolt, washer, and wing-nut (Fig. 3 inset). For each dowel, a brace was placed near the top of the cage and one just below the lower edge of the doorway, both just outside of the vertical edge of the doorway. We secured the dowels in the braces by bending the dowel a few centimeters from one end, then sliding the long, straight section of the dowel through the hole in the top brace, through the tube on the side of the door, and then through the hole in the bottom brace (Fig. 3). We ensured that the door would drop on its own once released from above the doorway and that it fully covered the doorway when resting at the bottom of the track. Covering the bottom edge of the door with electrical or duct tape ensured that no one would get scratched by the door.

Next, we attached the mechanism to hold the door up and then release the door to drop when target birds were inside. For this, we purchased a universal car keyless entry system that included a car door lock actuator, remote, and receiver (Geevorks Universal Car Keyless Entry System Kit, 4PCS 12V Car Door Lock Actuator with Remote, Central Locking System). After assessing the length needed by holding the actuator against the trap, the "connecting rod" that comes with the actuator was cut to the appropriate length and inserted through the swivel hole on the actuator, and a fork wire connector was fitted to the end of the connector rod (Figs. 2b and 3). The actuator was zip-tied to the side of the trap so that the fork wire connector would be close to the bottom edge of the door when the door was in the open position and the actuator was extended to its full length (technically the locked position if installed in a car). The fork wire connector held the sliding door in the open position: the dowel fits between the fork of the wire connector and the tube of the door rests on top of the fork (Figs. 2b and 3).

Finally, we wired the actuator using instructions in the kit. Briefly, wires from the actuator were connected to the remote receiver, and the receiver was connected to a 12-V battery (Continental Batteries, Sealed Lead-Acid Battery CB1213-F1, 12V 1.3AH) with alligator clips. We chose to switch out the wireless receiver from the kit with a simpler one (12VMonster Single Channel Remote Control Wireless On Off Switch Controller Set), using ring wire connectors to wire the receiver. We also wanted to make multiple traps but only use one receiver and battery, so we wired them in such a way that the receiver could be easily disconnected from the actuator by using a DC power jack plug adapter (California JOS 2 Male + 2 Female 12 V 2.1x5.5mm DC Power Jack Plug Adapter Barrel Connector for CCTV security camera) between the actuator and receiver.

**Setting up the trap for habituation and use**

Because birds may be wary of changes to bird feeders, an initial habituation phase was essential to allow birds to get used to entering the trap before deploying the traps for capture (even though we observed several species that quickly went into the traps with little to no habituation; see Results). In our study, we put the traps out at permanent feeder sites several times a week, for 6–8 hours per day, for about two months (from late January to March 2025) for habituation at five independent locations around suburbs of northwest Houston, Texas, USA. During habituation, we did not deploy the receiver or battery with the trap. We monitored traps at frequent intervals (approximately every 30 min) either by staying within eyesight of them but at a significant distance (ca. 15 to 25 m), or by using cellular camera traps or cellular security cameras to check trap usage from a cell phone. At one site, a feral cat began to watch/stalk the bird feeder, so we stopped leaving the trap unattended at that location. We did not leave the traps out overnight to prevent larger mammals (e.g., Virginia opossums, *Didelphis virginiana*) from getting to the feeder and damaging or getting stuck inside the trap. We used this habituation phase to be sure that at least several target birds were using the trap before we began capture attempts.

To set up the trap, we lowered the feeder (filled with millet seed, which is preferred by our target species; Whelan et al. 2015) into the trap, and slid the feeder's hanger up through the slot in the center of the plastic sheet. We suspended the feeder and trap combination on a shepherd's hook. We then opened the trap door and rested the door on the forked wire connector attached to the car door actuator, with the actuator in what would be the locked position for a car door (actuator extended to its greatest extent). When habituating, we also twist-tied the door in the open position so that it could not accidentally close. When setting up for capture, we secured the flap of the plastic lid closed with a twist tie. We put the 12-V battery on the ground, often inside a protective plastic box with holes that allowed wires to pass through and allowed for off gassing (12-V batteries produce gas and must never be run in an airtight container because gas build-up can cause damage to the container or create a pressure explosion). We secured the wires and the remote receiver against the shepherd's hook with hook-and-loop straps (Fig. 1). We then moved to a position away from the birds (ca. 10–30 m) but where we could see the trap and identify bird species with binoculars (often inside a nearby car or building, or behind a fence or foliage). When our target bird(s) entered the trap, we pressed the "unlock" button on the remote control to close the trap door.

**Capture methods**

After habituating House Sparrows to the traps, we captured them using both our traps and mist nets as part of another study with independent research purposes (Virginia Tech IACUC #24-108 [BIOL]). We captured birds at each of the five locations for a full day from 25 to 30 March 2025 (9–12 h per location depending on weather conditions). At most locations (depending on space within the yard), we set up two mist nets and one trap, placing mist nets in flyways that birds typically took toward the feeder on which the trap was set up. After this combination of mist nets and traps at each location, we subsequently captured birds using only traps and set them up typically for several hours at a time (2–5 h) rather than for a full day. During capture sessions, we recorded the species of each bird captured with both the mist nets and trap, allowing us to compare bycatch and target species capture numbers of these two capture methods. We did not record every bird that hit the net and escaped, nor every individual bird that entered and exited the trap without being captured, although we did record species that we observed entering and leaving the trap. We use the term bycatch to mean non-target birds that were captured, not those that hit the net and escaped, or entered and left the trap without being captured. We define trap-hours as the total number of hours that any and all traps were set up to capture individuals, and net-hour, similarly, is defined as the total number of hours that any and all nets were set up to capture individuals (e.g., 2 nets set up for 1 hour equals 2 net-hours). Overall, nets were deployed for 76.25 net-hours, whereas traps were deployed for 84.75 trap-hours.

Nets and traps were constantly monitored from a distance. When a bird was captured in the net, it was extracted as soon as possible (typically within seconds to minutes after capture in the net). Similarly, when birds were captured in the trap, they were extracted as soon as possible (within seconds to minutes). To extract birds from the trap, we lifted the trap door, put one arm inside the trap, and waited until the bird was against the mesh. Then, we quickly put a hand over the bird to stop its movement and gently enclosed the bird in hand.

Although it would be useful to compare the amount of bycatch avoided by using this selective trap compared to a non-selective trap on a feeder, we did not have a non-selective trap, and we did not count every non-target individual that entered and left the trap during the capture sessions. However, using video from one habituation session (20 March 2025, 09:10 to 16:00), we counted every target (House Sparrow) and non-target (other species) individual that entered the trap, to give an estimate of how much bycatch can be avoided by using this trap. This is a maximum estimate, because it is likely that birds entered and left the trap, moved out of sight in the video, and then returned and re-entered the trap. No birds were individually identifiable on the videos, so we cannot discount these repeated entries.

## RESULTS

### Habituation and observed species

Birds varied in their propensity to enter the trap once it was installed. At some locations, House Sparrows began to enter the trap after the trap was present for three (non-consecutive) habitation days, whereas at other locations no House Sparrows were seen entering the trap for the first 10 (non-consecutive) habituation days. Even after the habituation period, some House Sparrows were sometimes wary of going in. Other species were more likely than House Sparrows to enter the trap, even without habituation. The bird species that readily entered the traps included Northern Cardinals *(Cardinalis cardinalis*), Carolina Chickadees (*Poecile carolinensis*), Chipping Sparrows (*Spizella passerina*), Savannah Sparrows (*Passerculus sandwichensis*), Brown-headed Cowbirds (*Molothrus ater*), Scaly-breasted Munia (*Lonchura punctulata*), and House Finches (*Haemorhous mexicanus*). Additionally, an eastern gray squirrel (*Sciurus carolinensis*) entered, exited, and sat on top of a trap several times.

During the six hours and 50 minutes of video that we reviewed from the last habituation session at one site, we found that House Sparrows entered the trap 21 times and individuals from non-target species entered the trap 98 times. The vast majority were Brown-headed Cowbirds, but three Carolina Wrens (*Thryothorus ludovicianus*), one Tufted Titmouse (*Baeolophus bicolor*), two Scaly-breasted Munia, and one White-winged Dove (*Zenaida asiatica*) entered, as well.

### Capture rates and bycatch

Our capture results provide anecdotal data comparing the two capture methods. We captured three times more House Sparrows in the mist nets than in the traps (nets: 22 House Sparrows; traps: 6 House Sparrows; Table 1). Although the mist nets were more effective at capturing our target species than traps were, traps were completely effective at eliminating bycatch (0 vs. 19 bycatch; Table 1). Importantly, seven species entered and exited the trap without capture because we did not close the trap. We never had a case of a target and non-target individual entering the trap together during the trapping period, although we did see this occur during the habituation period.

**Table 1.** Capture data from remotely closing traps and mist nets during capture sessions in suburban yards of northwest Houston, Texas, USA. Capture sessions were designed to capture as many House Sparrows (*Passer domesticus*) as possible, not to experimentally compare the effectiveness of the two methods. Thus, these results are anecdotal and only have illustrative purpose.

| | Remotely closing trap | Mist net |
|---|---|---|
| Number of individuals captured of target species | 6[†] (5 females, 1 male) | 22[‡] (9 females, 14 males) |
| Number of bycatch individuals captured | 0 | 19 |
| Percent bycatch | 0 | 46 |
| Approximate hours in use (trap-hours and net-hours) | 84.75 | 76.25 |

[†] Because mist nets were often set up in the flight path to the feeder/trap, it is possible that some of the birds that were captured with the mist net would have been captured with the trap if the mist net had not been present.
[‡] Nets set up in flight path to feeder/trap. In some locations, two nets were set up.

## DISCUSSION

### Trap novelty

Most of the widely used bird capture methods (e.g., mist nets, automatic Potter traps, and other types of baited traps) are non-selective, meaning that bycatch is likely or potentially unavoidable. The remotely closing door technology that we developed to capture House Sparrows enhances a typical baited trap design. Specifically, our design is easy to use and allows for the selective capture of birds visiting a feeding station, effectively eliminating bycatch.

### Trap usability and performance

Trap set-up was quick and easy. The traps are lightweight and relatively portable, making them easy to transport to field sites. It took only one or two minutes for a single person to set up the trap for habituation and two to five minutes to set up the trap for a capture session. During habituation, little to no maintenance was needed other than frequent monitoring via cell phone or observation from a distance. Similarly, little to no maintenance, other than monitoring from a distance, was needed while traps were deployed. The 12-V battery lasted several trap days (perhaps one to two dozen activations of the door over several days).

The trap was robust. It suffered no damage from an eastern gray squirrel interacting with it. The trap door was never accidentally tripped by birds or squirrels touching it. It withstood wind and light rain. We did not fully water-proof the electronics, so we removed the trap when rain began (See Appendix 1 for more discussion of weatherproofing).

The trap was successful at closing quickly enough to trap the target bird all but one time. In this case, the bird was already heading toward the exit when we pressed the remote button, and exited before the door was able to fully close. Once the door of the trap closed, captured birds exhibited increased vigilance and began hopping from place to place inside the trap, presumably because of the unexpected movement and sound (though not very loud) of the actuator activating, the trap door dropping, and the researchers approaching the trap.

**Table 2.** Comparison of the advantages and disadvantages of remotely closing traps and mist nets.

| Remotely closing trap | | Mist net | |
|---|---|---|---|
| Pros | Cons | Pros | Cons |
| Little to no bycatch | Potentially lower capture rate, may require more time (depends on species) | Portable (depending on pole length) and lightweight | Extensive bycatch |
| Portable and lightweight | Requires battery | No battery required | Can cause stress, injury, and death |
| Can be made to researcher's specifications/ needs | Requires construction, cannot be bought pre-made | No construction required, can be purchased pre-made | Might capture large number of birds in same time period |
| Easy and fast set up (~5 min if feeder station is already set up, easy with only one person) | May require habituation period, depending on species | No habituation period required | Longer and more difficult set up (usually at least 10 min, and much easier with two people) |
| Little to no maintenance while waiting for birds to get captured | Primarily useful at pre-established feeding stations | Can use audio lures and decoys or use at feeder stations | Requires maintenance during capture period: sometimes requires debris removal and arranging net if disturbed by wind (to make it less visible to birds) and tightening support ties while waiting for birds to be captured |
| Can be deployed in a variety of habitat structures | Injury and mortality rate unknown; appears to cause stress | Useful for diversity studies and studies without target species | Often difficult or impossible to deploy in dense vegetation or tight spaces without habitat modification |
| Nearly no training required to set up. Lower level of training required for safely extracting birds than mist net. | | | Requires extensive training for someone to become efficient at setting them up and safely removing birds from the net |
| Can use food bait, decoys, and/or audio lures | | | Captured birds vulnerable to predation (Duarte 2013) |
| Captured birds less vulnerable to predation | | | More expensive than remotely closing trap |
| Less expensive than mist nets. Large cost advantage per trap if constructing multiple traps. | | | |

**Advantages and disadvantages of traps and mist nets**

As with most methods, whether this remotely closing trap is the best choice for a study depends on its advantages relative to its disadvantages (Table 2). The most obvious advantage is that the trap will greatly reduce or even eliminate bycatch because the researcher decides which individuals to capture once they enter the trap. Not only can non-target species be avoided, it might also be possible to avoid capturing non-target individuals of the target species (e.g., not re-capturing banded birds during banding sessions). Avoiding bycatch helps to ensure that research has reduced adverse impacts on the welfare of non-target individuals, thereby making selective trapping a more ethical way to capture wild animals. See Appendix 1 for extended discussion of trap versus mist net capture comparison.

Among other advantages, the traps are easy to use, with an easier learning curve than mist nets. Indeed, using mist nets requires extensive training to properly deploy and take down without damaging or tangling them. Deploying nets also requires learning knots to secure the guidewires to poles, and sometimes requires some strength to get poles into the hard ground. Most importantly, extracting birds from nets requires extensive practice and an understanding of bird anatomy and behavior, bird handling, and net entanglement. Thus, becoming an excellent user of mist nets takes extensive experience to gain knowledge and skill that can only be attained with practice. By contrast, a researcher can set up this trap after watching a set-up or reading instructions once. Further, it requires less knowledge, training, and practice to successfully extract a bird from the trap than the net because it only requires understanding of bird anatomy and behavior and proper bird handling. Nevertheless, extraction from the trap will become faster and easier with experience and anyone using the trap must be well trained beforehand in proper bird handling. Further, another advantage of the traps is that they can be modified to the researcher's needs: the size and shape of the trap, type of feeder, and perhaps the type of attractant can be changed (e.g., a bluetooth speaker playing calls and/or a decoy can be placed inside the trap to draw in birds that defend territories). Finally, the cost to build five traps with one interchangeable receiver and battery was about $150 US (i.e., $30 US each). A single trap plus receiver and battery would cost around $90, but because most of the materials only come in sets or large amounts (e.g., hardcloth comes in large rolls, an actuator kit with remote comes in a set of four), the cost to build multiple traps is lower per trap than the cost to build a single trap. Mist nets typically average around $100 each, plus the cost of poles, guidewires, and stakes, bringing an average net set-up to around $140 with no cost advantage to buying multiple. Table 2 compares pros and cons of remotely closing traps and mist nets.

**Outstanding questions**

There are still some questions to be answered about the use of remotely closing traps. For example, which birds will it effectively capture? It seems that individuals that are highly attracted to feeders and are curious/bold/neophilic are likely to enter the trap, similar to other baited trap types (but see Burns and Bonier 2020). Highly gregarious or social birds that do not defend food sources might also be effectively trapped in groups, because the presence of one bird on the feeder may draw more individuals in. In those situations, selective trapping at the feeder is ideal. However, like all capture methods, researchers should be aware of the risk of sample bias. For example, more neophobic individuals of the target species may be less likely to enter (but see, e.g., Brehm and Mortelliti 2018, Sockman and Beaulieu 2023). This problem might be mitigated by habituation periods or extending the trapping period. Similarly, some capture methods lead to sex or age ratio biases in captured individuals (DomèNech and Senar 1997). Anecdotally, we captured more females than males in our traps, whereas sex ratios were the opposite with the mist net (Table 1). More data are needed to determine if this trap has consistent sex- or age-biased capture rates, which will likely vary by species, and whether the bias can be mitigated with changes to the trap design or usage.

What is the injury rate compared to mist nets? According to Duarte (2013), most injuries that occur during bird capture by mist net and handling occur during the capture and extraction phases. Mortality and injury rates from capture and handling are not well reported, but where data are available, injury rates are typically less than 1%, and mortality rates are typically less than 0.3% for mist nets (Spotswood et al. 2012, Duarte 2013). We did not get a large enough sample size to estimate the general injury or mortality rate of the trap. We assume it is comparable to that of Potter traps and similar wire-type traps, though we were unable to find a published injury rate for similar types of traps. Although we did capture one bird with a relatively minor injury, we do not know if the injury was caused by the trap. It is likely that when multiple individuals are trapped at once, there is increased risk of injury because the birds might collide, increase each other's stress response, or fight. Indeed, the injured bird we captured was trapped with another bird, and they did fight briefly before the door was closed. We recommend that researchers report the injury and mortality rate in future publications for any capture method so that the safest methods can be determined, keeping in mind that injury and mortality rate for different capture methods likely vary by personality type, species, and populations. See Appendix 1 for extended discussion of disease and injury in captured birds.

Along with injury and mortality, stress because of capture is another harm to the bird, and how the stress experienced by birds in the trap compares to their stress in the mist net remains unknown. Past studies have established that remaining in a net activates the physiological stress response in birds, whereas remaining in a baited trap has variable effects on the stress response depending on species (Romero and Romero 2002, Angelier et al. 2010). Besides the stress impact of being contained in the trap, the two main sources of stress in the trap before extraction seem to be first, the movement and noise of the door closing, and second, the approach of the researcher to the trap, both of which the birds reacted to by jumping/flying from place to place within the trap. Because the physiological stress caused by this trap compared to capture by mist nets or other types of traps remains unknown, future studies should try to collect data to compare these potential welfare impacts.

**Selectivity and general applicability of remotely closing traps**

Although we did not directly compare our trap to non-selective traps, our habituation video data showed about four times more entries of non-target than target individuals. Had this been a non-selective trap, this would have resulted in extensive bycatch. None of the birds were marked, so we do not know how many birds entered multiple times, meaning the actual capture numbers would likely be somewhat lower, because there would be fewer repeated entries. Nonetheless, our data suggest that although a large number of non-target individuals may enter the trap, capturing them can be avoided because researchers only close the trap for target individuals. Thus, this trap is ideal for situations where the target population is a small subset of the overall bird community.

Beyond our study, we believe the success of the trap will depend on the target species: nets might be more effective for neophobic species or species that do not frequent feeders, whereas these traps might be more effective for gregarious, bold, and feeder-attracted species. However, regardless of the effectiveness of each method to capture target species, we feel confident that our selective trap will lead to far less bycatch than nets and non-selective traps. For many studies, this remotely-closing trap is likely to eliminate bycatch, thereby reducing stress, opportunity costs, injury, and death to wild animals, and allow researchers to focus their time and effort on their target species.

See Extended Discussion Topics in Appendix 1 for further details regarding weatherproofing, habituation, comparison of our capture rates using mist nets versus traps, disease and injury of captured birds, and comparisons to Potter and funnel traps.

**Author Contributions:**

*Bonnie Fairbanks Flint: conceptualization and engineering of door-closing mechanism, trap construction, bird capture and handling, writing - original draft of abstract, methods, results, discussion, writing - review and editing. Ben Vernasco: conceptualization of trap design, trap construction, writing - original draft of introduction, writing - review and editing.*

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**Data Availability:**

*The data/code that support the findings of this study are openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/PZK67. Ethical approval for this research study was granted by Virginia Tech Institution Animal Care and Use Committee, Protocol Number: 24-108.*

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## Appendix 1: Supplementary Material

### for *Bye-bye bycatch: A remotely closing trap for targeted songbird capture*

### Description of Materials

Note: all materials are available in large online retailers like Amazon.com.

- Galvanized steel hardware cloth: Metal mesh sold in a roll in hardware/home improvement stores. Sometimes inaccurately described as chicken wire, which is similar. Different gauges, mesh sizes, and lengths and widths might be needed for traps built for different sized birds. Metal-cutting tools, such as metal snips and nippers are needed to trim the hardware cloth to the correct sizes, which are also available in hardware stores.
- Corrugated twinwall plastic sheets: Plastic sheets that are similar to corrugated cardboard. Two layers of plastic separated by 4 mm corrugations. Can be cut with box cutters, craft knives, or similar tools. Found in hardware stores. Although cardboard can replace these plastic sheets, the cardboard cannot withstand rain, nor can it be easily cleaned.
- Report cover with sliding bar: Intended to enclose a paper report. Comes in typical paper sizes, but the item's size is not important for the construction of the trap because the sliding bars are cut down to the size of the doorway. Only the sliding bar was used for the trap. Can be cut with typical desk scissors, box cutters, etc.
- Perch suggestions: A straight peg hook designed for a peg board affixed with a zip tie. A garden staple bent about halfway along its length and with the open ends running in and out of the mesh below the doorway.

- Plant sticks for the tube of the door mechanism: Sticks/stakes of various materials and sizes intended to support a plant. The type we used were hollow and fiberglass. Many plant sticks are not hollow, so they will not work for the tubes required for the door mechanism. Any tube that is used for this purpose needs to be cuttable. Fiberglass worked well because we could cut it with a hacksaw.
- Metal dowels for the door track: Many dowels might work for this purpose, but they must have the following properties: cuttable, very straight, smooth and slick, bendable only under considerable force. Hardware stores carry metal dowels but we had difficulty finding ones with the correct properties there. Instead, we found a 36 inch metal wreath easel at a craft store. We were able to cut it with heavy duty nippers. A 45° - 90° angle bend near the top end of the dowel will prevent it from falling through the brace on the trap. The wreath easel has numerous bends in it, so it can be cut strategically to use the already-existing bends. However, if bending is necessary, it can be done by using two pairs of pliers to hold and bend the dowel.
- Universal car keyless entry system (includes a car door lock actuator, remote, and receiver): Available at Amazon.com and in some car parts stores. Many brands of these are available. Most come with two or four actuators. Most of them also have rather complicated receivers because they are designed to be simultaneously connected to all the doors, plus possibly the truck and the headlights. These extra wires can be ignored/removed, or a simplified receiver (below) can be purchased to replace the complex one. If multiple traps will be deployed at once and closed at different times, multiple receivers are required.

- Wireless receiver: The “12VMonster Single Channel Remote Control Wireless On Off Switch Controller Set” is a very simple-to-use receiver that we recommend. Available at Amazon.com.
- 12-V battery: In theory, a car battery could be used, but we recommend a smaller one with lower amperage for convenience, affordability, and safety. A very large range of amperage is available in these batteries, and we found that 1.3AH was sufficient for our needs. These types of batteries can be found at hardware and battery stores and hobby shops. These 12-V batteries have to be charged with a car battery charger or similar device, which is inconvenient. It would likely be far more convenient to use a USB power bank, but this conversion would require more extensive electrical expertise than we have.

**Extended Discussion Topics**

*Weatherproofing*

Car door actuators are designed to withstand some water and humidity, but are not completely waterproof. The receiver and battery are less resistant to water. In wetter conditions, all of these could be made more water- resistant with, for example, plastic food storage containers with small holes drilled in them to pass wiring through. However, experts advise against capturing during rainy weather (Fair et al. 2023), so extensive weatherproofing might be unnecessary.

*Habituation*

From our previous work with the House Sparrows, we knew that they were very cautious about any changes that occur to the feeder. If the target species is similarly wary, we recommend using a habituation period, in which the trap is put out regularly with the door(s) secured open (and optionally, the top flap can be left open) so the birds can become accustomed to going in and out. We recommend not leaving the trap unmonitored for extended periods of time in case an animal enters the trap and can't find its way out even with the doorway open (we noticed that some birds had trouble finding the door for exit). If predators might become present, we recommend staying close to the traps (e.g. being able to reach the trap within 30 minutes), because predators may attempt to use the trap to catch birds. If a predator is seen, we recommend removing the trap.

*Trap vs. mist net capture comparison*

The greater number of targeted House Sparrows captured in nets is likely due to multiple factors. First, we strategically set up the mist nets such that they were in known flight paths toward the trap, thus many birds that were on their way to the feeder/trap were captured by a net before arriving at the trap. The second reason is that, when mist nets were used, they were deployed for the entire day at most locations (and birds were often captured throughout the day), whereas when we used traps alone they were open only for a few hours at a time. Finally, House Sparrows in our area appear to be very wary of any changes to the feeder (e.g., changing out one type of feeder for another caused House Sparrows to stop feeding there for days or weeks), which is consistent with the high variability in House Sparrow populations and individuals in object and spatial neophobia (Dusang et al. 2025).

*Disease and injury in captured birds*

We trapped one bird that appeared unwell due to an unknown disease or other condition (poor body condition score, low weight, lethargy; these were not apparent before we chose to trap him). Because he was lethargic and made little attempt to escape the hand, extracting him from the trap was extremely quick and easy. Thus, it is possible that the trap decreases the amount of time sick birds experience capture-related stress, making it particularly useful for disease ecology studies. Furthermore, we were able to disinfect the trap relatively easily by wiping it down with a Lysol disinfecting wipe and then allowing it to dry, reducing the risk of disease transmission from capture. Conversely, for studies wishing to exclude visibly ill or injured individuals, selective trapping is ideal for avoiding such individuals.

All capture methods have some inherent injury risk, but injury rates are rarely reported. We assume that the risk of the remotely closing trap is similar to that of Potter and other walk-in traps. We observed one minor injury over the course of our study (injury description: very small crack in beak and small droplet of blood on the skin where the beak joins the soft tissue). When the bird entered the trap, there was already another bird inside the trap on the feeder, and the first bird attacked the entering bird. The closing of the trap door stopped the fight. The cause of the injury is unknown. The injury could have been present before trapping, could have occurred during the fight, or could have been caused by the bird trying to escape the trap. We are confident that the injury did not occur because of the door closing, because the bird never touched the door. The novelty of our design relative to other caged traps is the sliding door, and although it caused no injuries during our usage, the potential for injury associated with the sliding door is not known. We therefore encourage researchers using the design to report their injury rates so the risk associated with the novel closing mechanism can be assessed, mitigated, or discontinued if it causes many injuries. Importantly, we do not expect the injury rate to differ from the more commonly used Potter trap and injury rate is likely to vary by species for this trap, as it does for any capture technique (e.g. Duarte 2013).

*Comparison to other capture methods*

Mist nets were the only capture method that we used simultaneously to the remotely-closing traps we constructed, but based on past experiences with and literature about other traps, we can make some general comparisons in usability. After mist nets, food-baited Potters traps and funnel traps might be the most used capture method for song birds. These traps tend to be somewhat more expensive to purchase (typically over $100 per trap, depending on size) than our trap was to construct. One of the main differences between our trap and Potter or funnel traps is that both of the latter are typically placed on the ground, whereas our trap is suspended around a hanging bird feeder. Thus, our trap might be more likely to capture birds that avoid feeding on the ground, while Potter and funnel traps might be more likely to capture birds that prefer ground feeding. Whereas our trap is always selective, funnel traps are non-selective, but Potter traps can be either selective (the door held open with a rod that is pulled by a string when the researcher wants to close the door) or non-selective (a treadle releases the door when the bird steps on it). Potentially, our door and closing mechanism could be adapted to a Potter trap to make selective trapping easier. Our traps can either trap a single bird or multiple at once. By comparison, funnel traps can trap multiple birds at once, and Potter traps typically capture one bird at a time when used non-selectively, but can capture multiple individuals if used selectively. We presume that the injury and mortality rate would be similar among all of these traps due to the similarity of the materials and method of confinement, but injury and mortality rates for these traps are exceedingly rare in published literature. Stress caused by all three types of traps are likely similar. Based on past experience, Potter and funnel traps are similar in their ease-of-use to our trap regarding deployment and ease of bird extraction, although the fact that our trap is at human height rather than on the ground might make extraction slightly easier. Similar to our trap, Potter and funnel traps require little maintenance while deployed beyond monitoring, but don't require constant monitoring as our trap does, except if Potter traps are set up for selective capture. Potter and funnel traps are likely slightly more robust than our trap because of the complexity of our door mechanism and the electronics. Portability of Potter and funnel traps will vary depending on size, with smaller traps being at least as portable as ours, but larger traps being more cumbersome to transport than ours.