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TECHNICAL REPORT

Cage Restraints for Rhinoceroses

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Captive breeding programs for the rhinoceros can be enhanced by studying their reproductive physiology. To do so requires repetitive manipulations under physically controlled circumstances. To facilitate these procedures, zoos throughout the world have constructed restraint devices, or chutes. Chute designs are usually determined by the space in which they are to be situated and the budget available for their construction. In this study, eight chute designs at seven institutions were compared for efficiency in controlling rhinoceroses during ultrasonography, semen collection, and blood sampling. Procedures were conducted on 16 rhinoceroses of four species: the white rhinoceros (*Ceratotherium simum simum*), the black (*Diceros bicornis*), the greater one-horned Asian (*Rhinoceros unicornis*), and the Sumatran (*Dicerorhinus sumatrensis*). Chutes were evaluated for dimensions, fabricating materials, procedures to be attempted, and structural features such as shoulder restraints. Permanent, indoor, side-adjustable, pass-through chutes were determined to be the most efficient and convenient type because they saved time and reduced stress on the animals. Zoo Biol 17:343–359, 1998.

Key words: captive breeding; chute design; reproduction

INTRODUCTION

Gathering reproductive data that can improve management and reproductive performance plays an important role in rhinoceros captive breeding programs. Procedures such as ultrasonography, semen collection, and blood sampling often need to be conducted regularly and without the use of anesthesia. The use of a restraint device (chute) facilitates the performance of these procedures in domestic animals. Chutes have also been developed to manage chronic medical problems and to obtain data from giraffes, elephants, and rhinoceroses [Schmidt, 1981; Wienker, 1986; Adams

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et al., 1991; Schaffer et al., 1993; Radcliffe et al., 1995]. However, chutes are seldom incorporated into the initial design of zoo holding facilities; therefore, their characteristics are usually determined by the space available for them after the fact and the funds available for their construction.

We have had experience with eight rhinoceros chutes in seven institutions. Some of their characteristics were reported previously [Schaffer, 1988, 1993]. In this report we describe these chutes and compare their effectiveness and efficiency in restraining rhinoceroses during specific procedures.

ANIMALS

Manipulations related to medical procedures or research were conducted on 16 individual rhinoceroses of four species: the white rhinoceros (*Ceratotherium simum simum*); the black (*Diceros bicornis*); the greater one-horned Asian (*Rhinoceros unicornis*); and the Sumatran (*Dicerorhinus sumatrensis*). Animals were usually fed during procedures to reduce apprehension and facilitate handling. They had been habituated to handling by methods described for rhinoceroses and other animals [Wienker, 1986; Cody, 1995; Grandin et al., 1995; Michel and Illig, 1995; Nicholson, 1996]. A habituated animal may be expected to enter the chute readily and to tolerate being touched, as well as to accept adjustments to the chute before procedures are performed. Training tended to break more frequently in fractious animals (initially unapproachable within the cage and intolerant of being touched) than in tamed animals. Adverse actions included sitting, lying down, climbing, rolling over, placing horn and feet outside the chute, refusing entry, swinging the legs, and stomping the feet. These adverse actions were mitigated through animal rehabituation and/or chute modification.

PROCEDURES

Procedures performed included ultrasonography, semen collection, and blood collection. Access to the anus of both male and female animals was required to examine reproductive anatomy. Ultrasound probes were attached to an extension to image ovaries [Schaffer and Beehler, 1990; Schaffer, 1992].

The methods used for semen collection included penile massage, rectal massage, and electroejaculation [Schaffer et al., 1990; 1993]. All these procedures required access to the penis from the lower side and rear of the body. In addition, rectal massage and electroejaculation required access to the animal's rectum.

Blood collection sites were typically the ear, foreleg, and tail. Coccygeal blood collection from the ventral base of the tail and auricular blood collection from the ear were performed. Cephalic blood collection from the medial side of the forelimb, as described by Miller et al. [1989], was also used.

FACILITIES

Eight chutes at seven institutions were compared: Cincinnati Zoo, Cincinnati, OH; Henry Vilas Zoo, Madison, WI; Houston Zoo, Houston, TX; Oklahoma City Zoo, Oklahoma City, OK; Sedgwick County Zoo, Wichita, KS; St. Louis Zoo, St. Louis, MO; and Sungai Dusun Preserve, Malaysia. Measurements and characteristics of chutes are given in Table 1.

TABLE 1. Characteristics of rhinoceros chutes evaluated in this report

Chute	Location	Animals, sex and species	Chute size (cm) (W×L×H)	Gate type	Chute material
1	Indoor	Female black	120×270–335×200	Rear: hydraulic sliding vertical bars (10 cm diameter); front: solid adjustable sliding	Vertical steel bars, 15 cm diameter, 33 cm apart
2	Indoor	Male and female Sumatran	90–108×200–260×210	Rear: adjustable sliding panel, removable vertical bars (7 cm diameter); front: solid sliding	Vertical steel bars, 10 cm diameter, 12 cm apart; 1 movable cement side wall
3	Indoor	Male and female southern white	133×390×240	Front and rear: guillotine type, large central opening in rear guillotine (73×152 cm)	Vertical steel bars, 6 cm diameter, 32 cm apart; shoulder restraints
4	Outdoor	Male and female southern white	128×308×150	Rear: 2 sliding horizontal pipes (8 cm)	Horizontal and vertical steel, pipes, 8 cm diameter, 15-cm diameter corner posts, open sided with a chain
5	Indoor	Male and female greater one-horned	100×275×170	Side: swinging, 6 horizontal pipes, full length of chute (6 cm diameter)	Collapsible, other side is passage wall, rear vertical 6-cm diameter pipes, small opening (35×123 cm)
6	Indoor	Female black	115×250–335×243	Front, rear, and middle: guillotine type, vertical bars (6 cm diameter)	Collapsible, vertical aluminum bars, 6 cm diameter, 33 cm apart
7	Outdoor	Female and male black	95×450–240×210	Middle: guillotine-type door; front and rear: exhibit gates	Vertical aluminum bars, 6 cm diameter,33 cm apart
8	Outdoor	Male and female Sumatran	120×252×130	Rear: 3 removable pipes (15 cm diameter)	Vertical iron pipes, 15 cm diameter, 20 cm apart

Chute 1: Cincinnati Zoo

The Cincinnati Zoo chute, constructed of steel and used for a female black rhinoceros, acted as a passageway between two much larger indoor pens. Before the animal's entry, the length of the chute was incrementally adjusted from the front with a sliding solid panel. The hydraulic, barred backgate was then closed after entry. Because ultrasonography was performed solely through the vertical bars in this gate, the animal could be positioned in the chute in only one direction. The excessive width of the chute allowed the animal to swing her rump back and forth, making ultrasonography both difficult and potentially dangerous for the examiner (Fig. 1). However, because this animal was tame, she eventually learned to lean against the backgate and remained stable long enough for ultrasonography to be performed [Schaffer and Beehler, 1990] but would not tolerate being examined repeatedly. Widely spaced vertical steel sidebars at the front of the chute enabled an operator to enter the chute easily to collect blood from the cephalic vein [Godfrey et al., 1993].

Chute 2: Cincinnati Zoo

Another steel chute, which was part of a larger indoor holding facility at the Cincinnati Zoo, was built for tamed Sumatran rhinoceroses. The animals passed through the chute daily and rarely refused to enter it. One side of the chute consisted of fixed, close-set vertical bars with a swinging door at one end. This door provided clear access to the rear half of one side of the animal (Fig. 2). With the use of the side door, semen was successfully collected from the male [Schaffer, unpublished data, 1994]. The opposite side of the chute consisted of a movable cement wall that was used to adjust chute width, as can be seen through the cage bars in Fig. 2. A hand-crank system controlled movement of the wall, as occurred when the chute had to be narrowed to prevent escape during procedures conducted through the swinging door. Narrowing the width also prevented lateral movement of the animal so that

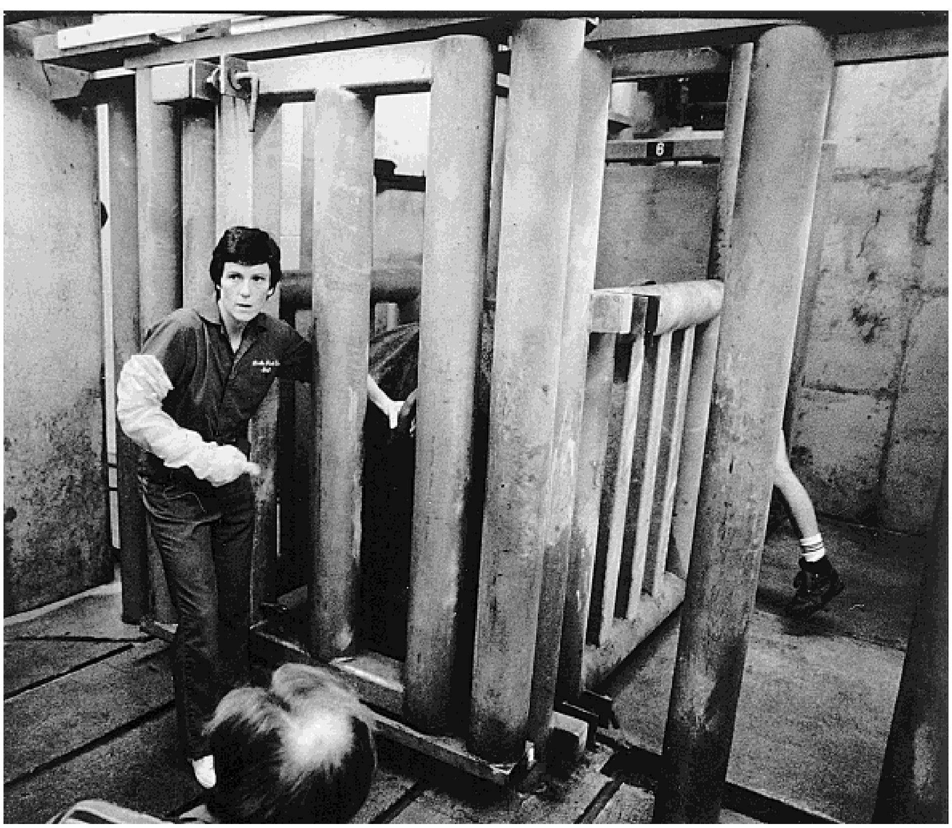

Fig. 1. Chute 1. Large bars in the rear gate pin the operator when animals move side to side.

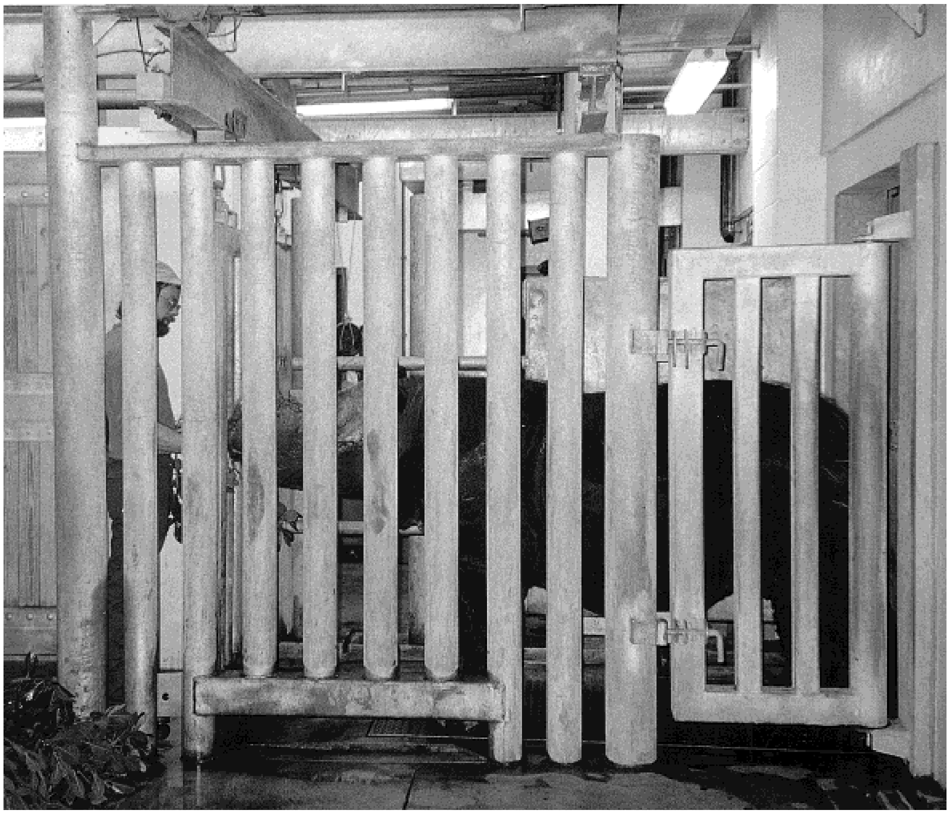

Fig. 2. Chute 2. Sidegate at one end opens to provide free access to one side of rear of the animal.

ultrasonography and blood collection could be performed by pulling the tail out through the bars of a sliding steel endgate [Schaffer, unpublished data, 1994; Campbell, unpublished data, 1994]. This endgate allowed incremental adjustments in chute length (executed before the animal entered the chute) and consisted of several removable vertical bars (7 cm in diameter) that, when individually removed, improved access to the rear of the animal. A solid door at the opposite end precluded the performance of any procedure from that location.

Chute 3: Henry Vilas Zoo

The Henry Vilas Zoo chute, designed for the southern white rhinoceros, was positioned in an off-exhibit passage from indoor to outdoor exhibit areas and consisted entirely of steel vertical bars. This chute was excessively long (one and a half times the length of the animal), but this feature allowed sufficient time to close the endgate before it could escape from the chute. Exit gates were of the guillotine type with large central openings (Fig. 3). These gates were backed by solid sliding doors to the exhibit area. The doors moved easily and were occasionally slid open by persistent rhinoceroses. The sliding door in front of the animal was closed to prevent the animal from raising the guillotine gate or from becoming wedged in the central opening. Keepers had to exercise care not to get in the way of the sliding door.

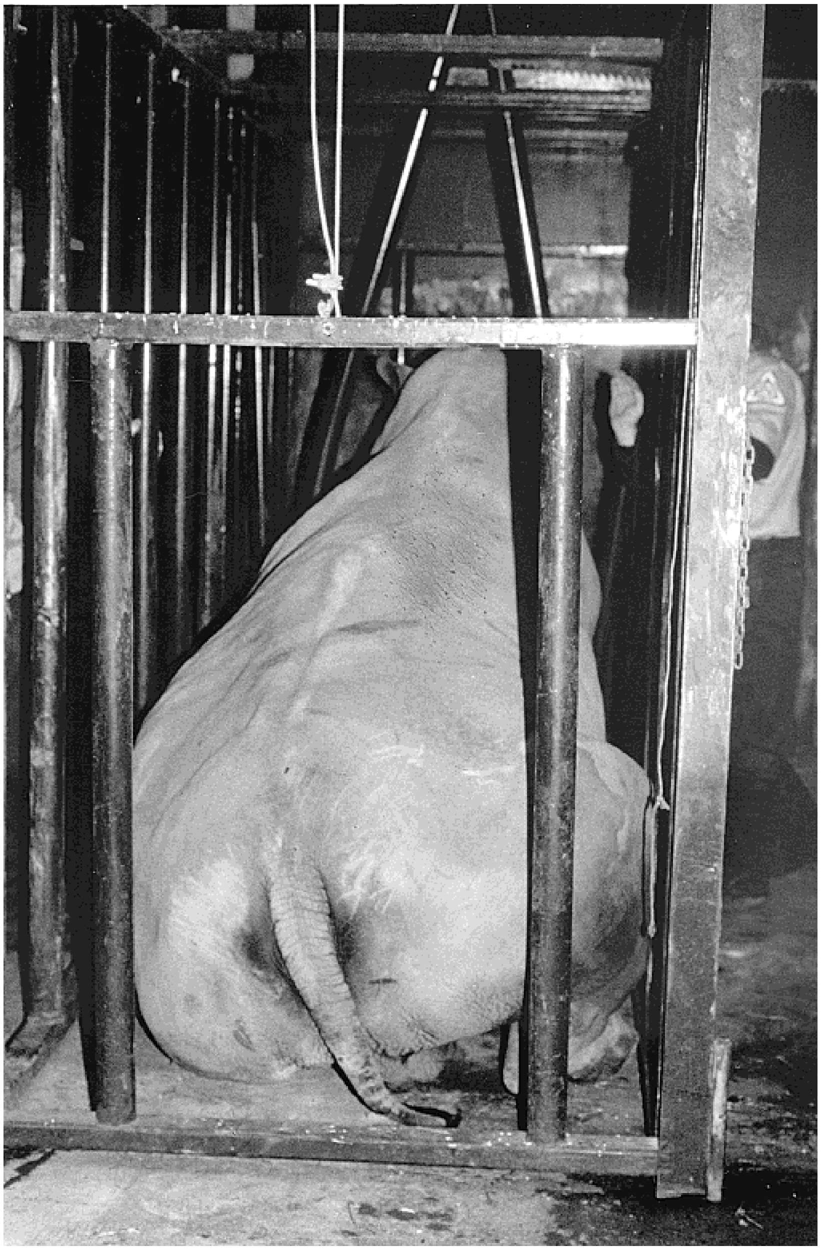

Fig. 3. Chute 3. A wide, operable space in the guillotine gate is needed with this wide chute.

Fractious rhinoceroses of both sexes passed through this chute daily from inside to outside yards. The chute could not be used in freezing weather, thus limiting restraint procedures to warmer times of the year.

To control the excessive forward movement of these animals while in the chute, shoulder restraints were positioned to brace against the cervical hump (Fig. 3). If these restraints were moved to the other end of the chute, it could be used with the animal positioned in the opposite direction. The release plates holding the shoulder restraints in place were racked for adjustability and quick release if the animal became overly excited (Fig. 4). Releasing the shoulder restraints tended to calm a struggling animal. The restraints could then be reset and the procedures continued. Problems with the shoulder restraints included wedging of the animal in the half-opened restraint between the side of the chute and the one closed restraint bar. Also, panels had to be placed on the outside of the shoulder bars to keep the animal from hooking a horn behind the bars or from placing a foot between the bar and the side of the cage.

Rectal ultrasonography was performed regularly on the female and periodically on the male [Schaffer and Beehler, 1990; Adams et al., 1991]. The extra width of the chute unfortunately allowed the animals to swing their rumps from side to side. The opening in the rear gate was enlarged to 73 × 152 cm to prevent pinning of the operator's arm during palpation (Fig. 3). Since the animals tended to lie down or sit during restraint, the lower bar was placed only a few inches from the floor.

Blood from the ears from both animals [Schaffer, unpublished data, 1995] and semen from the male [Schaffer and Beehler, 1988; Jones and Bavister, 1988] were obtained through the widely spaced vertical sidebars of this chute. The space was wide enough for operators to slip easily in and out of the chute. The animals' feet and legs also slipped readily through this space, particularly when they lay down and rolled onto their sides. To prevent this, short horizontal bars were placed between the vertical bars, creating smaller spaces (5 × 15 cm). However, an animal's middle toe became lodged in this small space, precluding standing up until it had kicked itself free with the other leg. The divisions between the vertical bars were subsequently removed to prevent recurrence. This incident necessitated rehabituation to the chute.

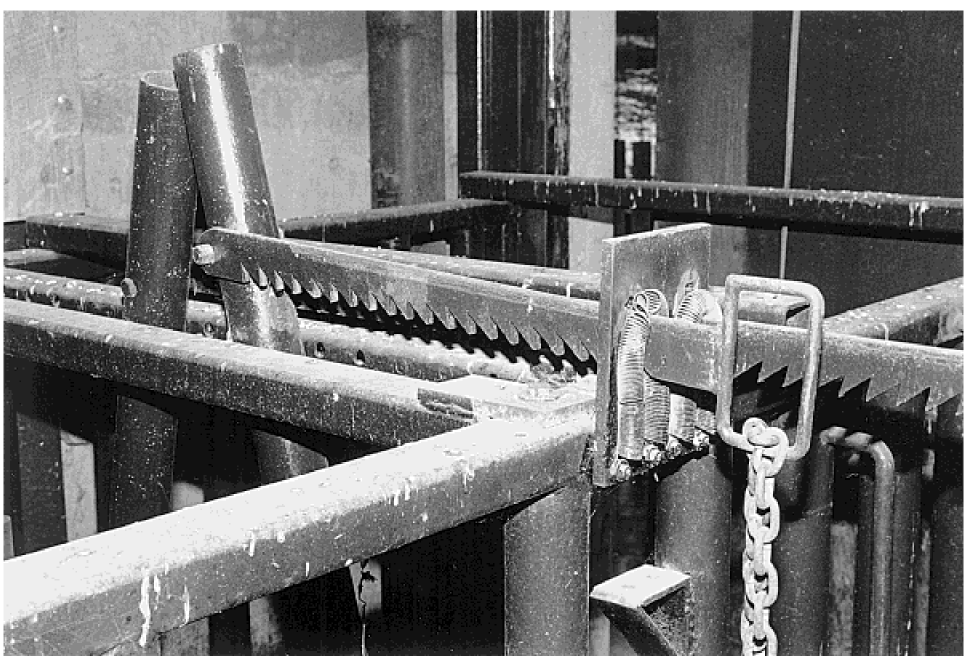

Fig. 4. Chute 3. Racked (saw-toothed) panels provide rapid release of shoulder restraints.

Chute 4: Houston Zoo

The Houston Zoo chute, built for southern white rhinoceroses, was an outdoor pen made of horizontal steel pipes and chains supported at the four corners by vertical steel posts embedded in the ground (Fig. 5). Since this chute dead-ended into an outdoor yard, it was used only periodically and not in inclement weather. Animals would not always enter the chute. Once an animal had entered, two horizontal pipes were slid into place at the rear of the chute to contain it. Because the chute was only as long as the animal, it was difficult to encourage enough forward movement to allow the pipes to be slid into place. The chute was about the same height as the rhinoceroses. It was just wide enough to allow the animals to lie down but not to roll over.

An operator sat on a side pipe to reach across a chain and under the animal to massage the penis for semen collection (Fig. 5) [Schaffer and Beehler, 1988]. Blood was collected from the ear, but the upper horizontal pipe interfered with access, so that regular collection was not pursued [Blasdell, unpublished data, 1989]. Rectal ultrasonography was not performed regularly because animals frequently sat down and the rear horizontal pipes were positioned just under the tail, preventing access to the rectum.

Chute 5: Oklahoma City Zoo

The Oklahoma City Zoo chute was a collapsible steel structure hinged to the walls within the off-exhibit passages of the building. It folded out from the wall across the passageway and attached to the opposite side. An internal swinging gate and the wall of the passage then formed the sides of the chute (Fig. 6). This design

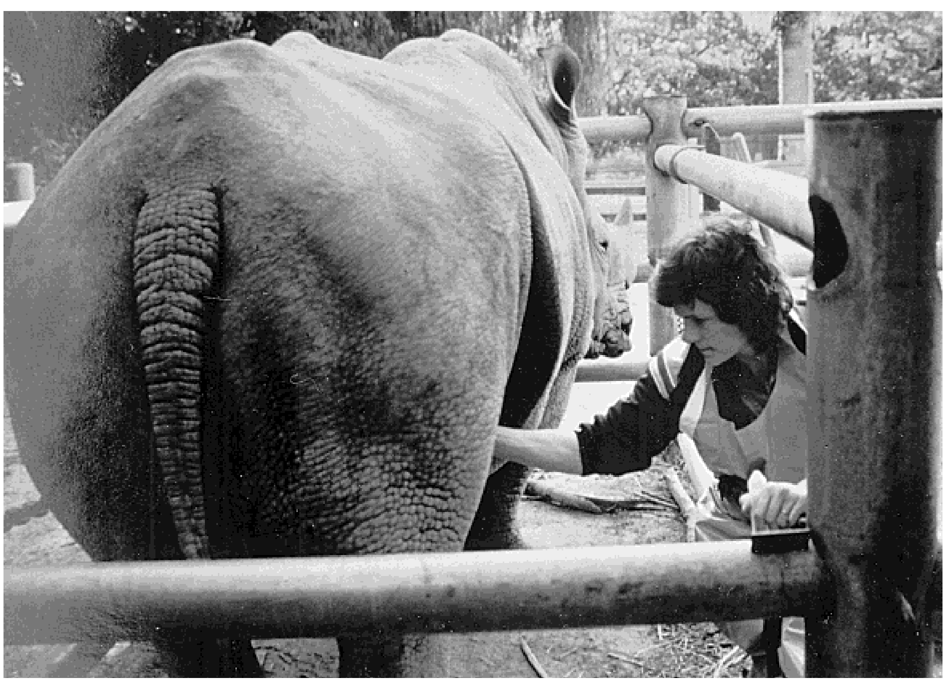

Fig. 5. Chute 4. The open sides of this short, dead-end, outdoor chute allow easy access to animals. Crossbars at rear of animal interfere with palpation.

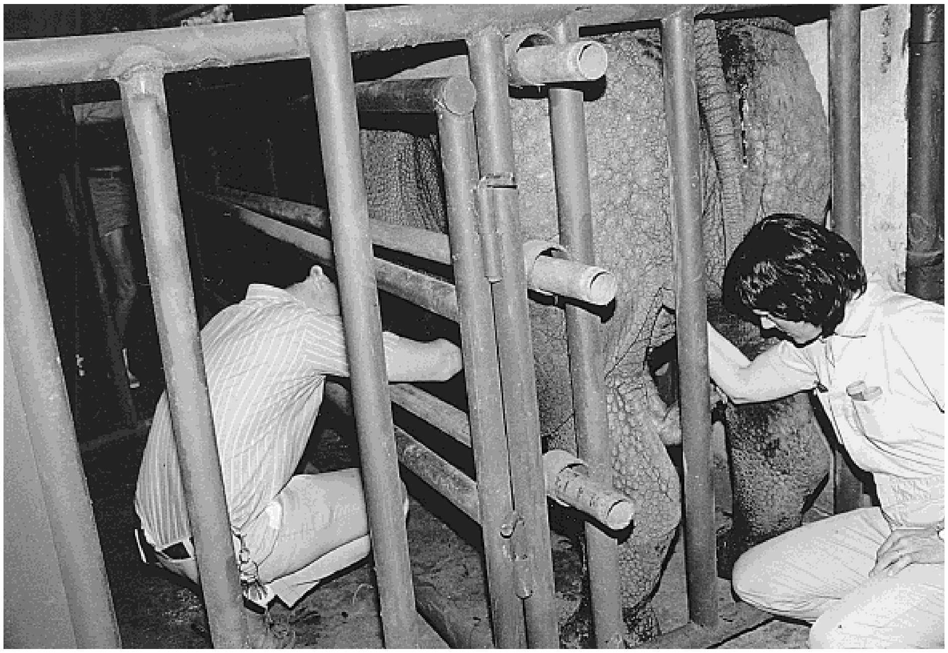

Fig. 6. Chute 5. Only a small space was needed at the end of this tight chute. Sidebars interfere with access from the side.

made the wall side inaccessible. Tamed greater one-horned rhinoceroses entered the chute from the indoor exhibit area through a swinging door that was difficult to open and was often slammed shut by the animals. Once the animals were in the passageway, operators had to push them against the wall with the internal swinging sidegate. In doing so, the operators' arms were placed in potentially dangerous positions. This internal sidegate was supported by three additional pipes, slid into place (Fig. 6). The chute was tight, allowing only a few inches on either side of the animal, and was eventually outgrown by the female. The animals could not lie down, and their hips sometimes became wedged if they tried. The opening in the backgate was very narrow (35 × 123 cm), but because of the tight fit, the risk of an operator being pinned while reaching into the chute was substantially reduced, compared with that in chutes with room for animals to shift their bodies. The opening also went all the way to the floor to provide access if the animal were to lie down. Ultrasonography was successfully performed on both animals [Schaffer and Beehler, 1990], but since this dead-end structure was not used daily and it often took hours to load the animals, it was not used repeatedly.

Semen was collected through the two bottom bars of the sidegate [Schaffer and Beehler, 1988]. However, these bars interfered with reaching under the animal to support the penis for penile massage (Fig. 6). Insufficient chute height allowed the female on two occasions to place her chin on top of the chute, permitting her to leverage her body high enough to place a leg and then the front of her body on top of the chute. Both times she dismounted without incident. Bars were too close together in the front and along the side of the chute to allow free access to the ears or legs for blood collection. However, blood was collected from the tail [Barrie, unpublished data, 1988].

Chute 6: Sedgwick County Zoo

The Sedgwick County Zoo chute, made of aluminum, was collapsible and, when set up, extended across an off-exhibit passage between indoor and outdoor exhibit areas (Fig. 7). A tamed female black rhinoceros passed through the chute daily and rarely refused to enter it. The sides of the chute, hinged onto the passageway walls, swung in from their storage position and were then secured to the middle of the passageway floor and to each other. The chute was long, allowing ample time to close the backgate after the rhinoceros had entered. The ends were flared to make the chute flush with the exhibit doors. Each end was closed with a guillotine gate as part of the chute, plus a solid horizontal sliding door of the exhibit (each end thus had two doors). Personnel had to avoid the path of the sliding doors because they could be slid open by the rhinoceroses. The endgates and sides were made of widely spaced vertical bars.

Excessive chute width at the flared ends permitted the animal to move its rump back and forth past the vertical bars of the guillotine endgate. Two crossbars placed at one end of the chute resolved this problem, but they decreased the overall chute length (Fig. 7). Consequently, the animal sometimes escaped from the chute before the endgate could be closed, thereby increasing the loading time. After the crossbars were installed, rectal ultrasonography was performed on the female several times during an estrous cycle and pregnancy [Schaffer and Bryant, 1994; Schaffer et al., 1995; Berkeley et al., 1997]. Her vagina was also examined and treated for infection. The top crossbar passed just above the base of the animal's

Fig. 7. Chute 6. Collapsible chute sides are attached to each other across the passage. Widely spaced bars of the sides allow easy access.

tail, and the lower crossbar passed just above the hock. The female backed up in response to palpation, traumatizing the base of the tail. When the top crossbar was removed, she sat precariously on the lower crossbar. Because of these problems, the crossbars were replaced with a guillotine gate, hinged to one of the collapsible sides of the chute.

Blood for hormone analysis was drawn from the forelimb by cephalic collection [Berkeley et al., 1997]. Collection was performed through the wide spaces of the vertical sidebars. The space between these bars was sufficient to allow the operator to easily cross under the animal and over to the medial side of the opposite leg.

Chute 7: St. Louis Zoo

The St. Louis Zoo chute was constructed in an outdoor exhibit area, extending from the entrance to the indoor exhibit to an outside gate. It had a guillotine backdoor in the middle of the chute, dividing it in half, and was made of aluminum vertical bars. The chute was built for semen collection and reproductive examinations of black rhinoceroses; however, it was difficult to get the animals to enter the chute. Because of the disposition of the animals and limited keeper time, these animals never became sufficiently acclimated to its use.

Chute 8: Sungai Dusun Preserve

The Sungai Dusun Preserve chute, built for working with tamed female and male Sumatran rhinoceroses, was made of galvanized iron pipes. It was situated on a cement slab in the outside area of a compound and led to the indoor passageway. Because the chute was overly long, a second row of removable pipes was placed at the front (the entrance to the indoor passage) to shorten it by 50 cm. The three endpipes were removable from holes in the cement and could be reset after an animal entered the chute. Upon removal of the middle endpipe, blood could be collected from the tail vein [Zainuddin, unpublished data, 1993] and ultrasonography performed [Schaffer et al., 1994]. Semen was collected through the sidebars, but their close spacing made this difficult (Fig. 8) [Schaffer et al., 1992].

EVALUATION OF CHUTES

Length

Chute length is a compromise between providing sufficient length for closing the endgates before the animal could escape and the need to reduce its forward movement once closed into the chute. Animals often refused to completely enter short chutes such as those at the Houston and Oklahoma City zoos. These chutes were only as long as the nose-to-rump dimensions of the animal. In these chutes, closing of the gate was also prevented when rhinoceroses stretched their bodies to obtain food without completely entering. Longer chutes, such as those at the Sedgwick County Zoo and the Henry Vilas Zoo, provided enough time to secure the gates before escape but allowed excessive forward movement of the animals. Operators trying to contact the animal from the side were imperiled, whereas those working on the rear (i.e., for palpation or blood collection) ran the risk of being dragged into the chute. Thus, forward movement had to be controlled in longer chutes. Less chute length was needed if the gate could be closed rapidly. However, retreating animals could be injured as the gate was being closed.

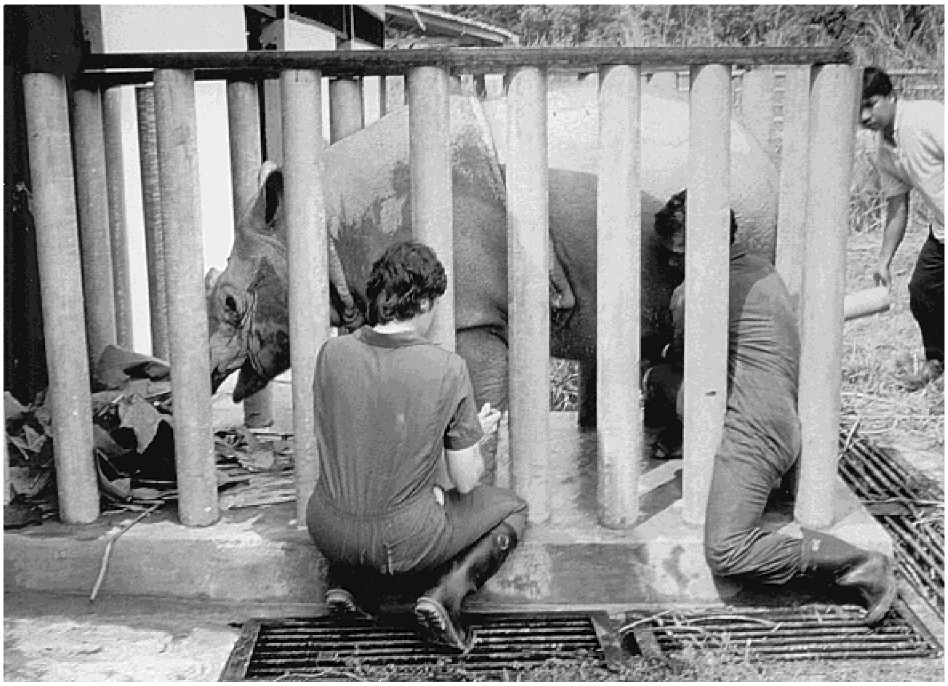

Fig. 8. Chute 8. Closely spaced sidebars interfere with semen collection. Posts removed from the rear of the chute provide a gap for ultrasonography.

Methods of Stabilizing the Animal

Forward movement was reduced prior to chute entry by moving either a rear or front panel, but this required the animal to completely enter a shortened chute and remain standing for closure of the backgate. Eyres et al. [1995] reported shortening the chute after the animal entered by forward movement of a rear panel manually. This allowed adjustment for different-sized rhinoceroses and better control of the animal within the chute. A squeeze panel should not bind with pressure and should have an automatic release mechanism for use if the animal becomes wedged or excited [Schmidt, 1981]. Unfortunately, squeezing mechanisms can push the head of the rhinoceros down into uncomfortable positions. As a consequence, shoulder restraints were developed as a more comfortable system for restraining rhinoceroses.

Restraining animals at the shoulder is commonly used for domestic bovids and has been used for some wild species [Read et al., 1989]. This method is effective because the rump-to-shoulder length remains constant, while the rump-to-nose length varies when the animal lowers its head. This restraint device is referred to as a “headgate” and is usually snapped shut, catching the animal at the shoulder just after the head has passed through. The large body size of the rhinoceros precluded the use of headgates in this manner. However, rhinoceroses tend to back up once restrained, allowing placement of shoulder restraints.

Width

Chutes should be narrow enough to reduce side-to-side movement, yet wide enough to allow the animal to lie down but not roll over. Animals sometimes refused to enter chutes that were too tight (<10 cm on either side of the animal), or if they did enter, they sometimes became wedged when trying to lie down. In chutes with fixed sides, the width of the chute must be carefully coordinated with the width of the animal.

Chutes with fixed sides that were too wide required wider rear openings in the endgate (access for palpation) to compensate for greater lateral movement of the restrained animals (Henry Vilas Zoo). Similarly, narrower chutes required proportionately smaller openings (Oklahoma City Zoo). With some chutes, the openings in the endgates could be made to correspond with chute width through the use of removable or adjustable bars. The backgate of the Sungai Dusun Preserve chute had removable posts in the ground, whereas the Cincinnati Zoo chute (Chute 2) had removable pipes in the gate that allowed adjustment of this space.

Adjustable sides, such as those at the Cincinnati Zoo (Chute 2), allowed flexibility in chute width and thereby accommodated a wider range of animal sizes and better control of the restrained individual. Adjustable chutes may create wedging problems, but these can be prevented by use of a pressure relief valve [Schmidt, 1981]. Use of chutes with nonbinding adjustable sides could provide effective restraint of rhinoceroses.

Endgates

A variety of endgates has been used to facilitate the entering and leaving of chutes. Sliding doors may be operated manually or hydraulically. Hydraulic doors have the disadvantage of a slow response time. Freely movable manual doors can be opened or closed quickly but are dangerous to the door operator in situations in which the animal is able to slide the door with its head or body. Guillotine doors generally have a faster response time than sliding doors for stopping animals. They require a tall structure and must be counterweighted to prevent operator fatigue and to prevent the door from being accidentally dropped on the animal. None of these doors can be moved if animals are leaning against them, but a powerful hydraulic door could be more readily engaged under these circumstances.

Height

The low heights of some chutes (Oklahoma City Zoo and Houston Zoo) allowed animals to climb on top of them. In addition, the animals took advantage of any features that would assist in climbing the structure. For example, they stepped onto crossbars or outcroppings of a few inches, leveraged their heads on the top of structures to lift their bodies, or reared up slightly on their hind legs. White and greater one-horned Asian rhinoceroses were able to mount structures with heights of 128 and 100 cm, respectively. The smaller Sumatran rhinoceros did not mount chutes of 120 cm in height. A height of 244 cm was sufficient to preclude climbing for all three large species.

Materials and Construction

Chutes were constructed of steel or aluminum bars or chains. Steel bars were most commonly used. Although aluminum is expensive and less malleable than steel, it produces less noise, and a quiet environment is particularly helpful during training of fractious animals [Elsinger, pers. comm., 1994]. Bar diameters ranged from 6.3 to 15 cm. Small diameters were effective in holding animals, since only the weight of the animal was usually being supported. However, bars of this size can be bent by a charging rhinoceros.

Both vertical and horizontal bars were used in constructing chutes. Because rhinoceroses may sit on their haunches, positioning the anus only a few inches from the ground, operators performing rectal palpation were at risk when bars passed under the tail. A horizontal bar below the level of the anus must be very close to the ground or else the animal must be prevented from sitting or lying down. One rhinoceros in this study sat on a crossbar just above the hock. Eyres et al. [1995] described the use of V-angled crossbars in the backgate to prevent the rhinoceros from resting its rump.

Horizontal bars along the side reduced the likelihood of pinning the operator when animals moved back and forth but were in the way when the operator tried to reach under the animal to gain access to the abdomen or penile sheath. Vertical bars seemed to provide easier access but had to be widely spaced to prevent a foot from being caught if the animal rolled over on its side. This, in turn, created a large enough space for the animal to extend a nose and horn, presenting a problem if it was fractious or struggling. Narrowing the spaces was ineffective because the flexible toes of the rhinoceros could be worked into spaces as small as the size of the toenails, or a foot could be jammed into a space half the size of the foot pad. In other instances, these spaces were covered by panels [Grandin et al., 1995; Calle and Bornmann, 1988].

A large, swinging gate in the Cincinnati Zoo chute (Chute 2) provided easy access to the side of a Sumatran rhinoceros. However, gates of this type must not be wider than half the length of the animal, and the chute must be fairly narrow, or the animal can work its way out. Gates of this size should not be used if the animal tends to roll.

CONCLUSIONS

Permanent, indoor, pass-through chutes, such as the one at the Henry Vilas Zoo, were the most efficient. Since rhinoceroses were exposed daily to these structures, they remained familiar with them. The animals could be loaded quickly, thus expediting procedures and allowing completion of several extensive projects. These chutes also were less stressful to the animals and reduced the time required to complete procedures.

Some zoos have built dead-end chutes to comply with existing architecture. However, these chutes never efficiently handled the animals and were therefore inconvenient to staff. Such factors make major reconstruction of existing architecture worthwhile. Extending a building may be less expensive than hiring another keeper to make up for lost keeper time in maneuvering an animal. Ideally, construction of a chute should be planned along with construction of the holding facility.

The following features should be incorporated into a chute design. However, because of the variety of adverse actions exhibited by rhinoceroses, managers may be required to modify their chutes for particular situations.

1. The chute should be located indoors to permit use in any weather.

2. The chute should be designed in such a way that all procedures can be performed with the animal positioned either way.

3. The chute must be wide enough to allow animals to lie down but not to

move excessively. Determination of appropriate width is critical in fixed-sided chutes. An average of 15 cm of space between the animal and the side of the chute is usually sufficient. The chute must be long enough (one and one-half times the length of the animal) to allow the entrance gate to be closed before the animal backs out, yet short enough to prevent forward movement. Variation in width and length is best dealt with by squeezing the sides and ends of the chute. Shoulder restraints are a less expensive alternative to squeeze mechanisms. Shoulder restraints should be designed to accommodate the morphological characteristics of the species for which they will be used. They should also be quick releasing to facilitate the calming of agitated animals.

4. Squeeze mechanisms should not bind under pressure from the animal.

5. Endgates should open and close quickly. This can be accomplished by counterweighted guillotine gates or freely sliding horizontal doors. Rhinoceroses must be protected from dropping doors, and personnel should be protected from sliding doors. Whether chutes are fixed or adjustable in width, the opening in the endgate should be as widely adjustable as possible and backed up by a solid door to prevent injury to the animal. The gate should contact the animal on muscle or fat pads to prevent injury.

6. Endgates should have openings large enough to allow access to the rectum or tail of the animal without impingement. This opening must be blocked by a solid door in circumstances when the head of the animal is presented.

7. Vertical bars should be spaced several centimeters farther apart than the diameter of the foot of the animal to be restrained. Small openings in the chute should be avoided because a toe or foot can be wedged into them. Removable panels may be an effective way to cover this space, but they are expensive. The cost may be reduced by the use of wood panels.

8. The height of the chute should be 60–90 cm higher than the height of the animal.

9. Access to light and electrical outlets and good drainage of water are advantageous.

Most of the custom designs we studied could ultimately be used effectively because of the nature of the animals and the efforts of staff. However, a commercially designed structure, built for the rhinoceros and including hydraulic doors, breakaway sides, removable panels, and sidebars, is available (C & S Cattle Handling Equipment, Cummings & Son, Inc., Garden City, KS). Another design that squeezes from both the sides and the rear is also available (Tod Ricketts, C.F. Jordan Inc., El Paso, TX). This design has removable side and end panels. These complicated chutes have been designed to deal with many of the problems described in this report but are expensive. The cost of commercially available chutes may be prohibitive for many institutions. However, costs may be offset by the fact that these chutes can expedite the training of animals, particularly fractious ones.

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