MANUAL FOR CHUTE DESIGN FOR THE RHINOCEROS

COMPILED BY
DR. NAN SCHAEFFER

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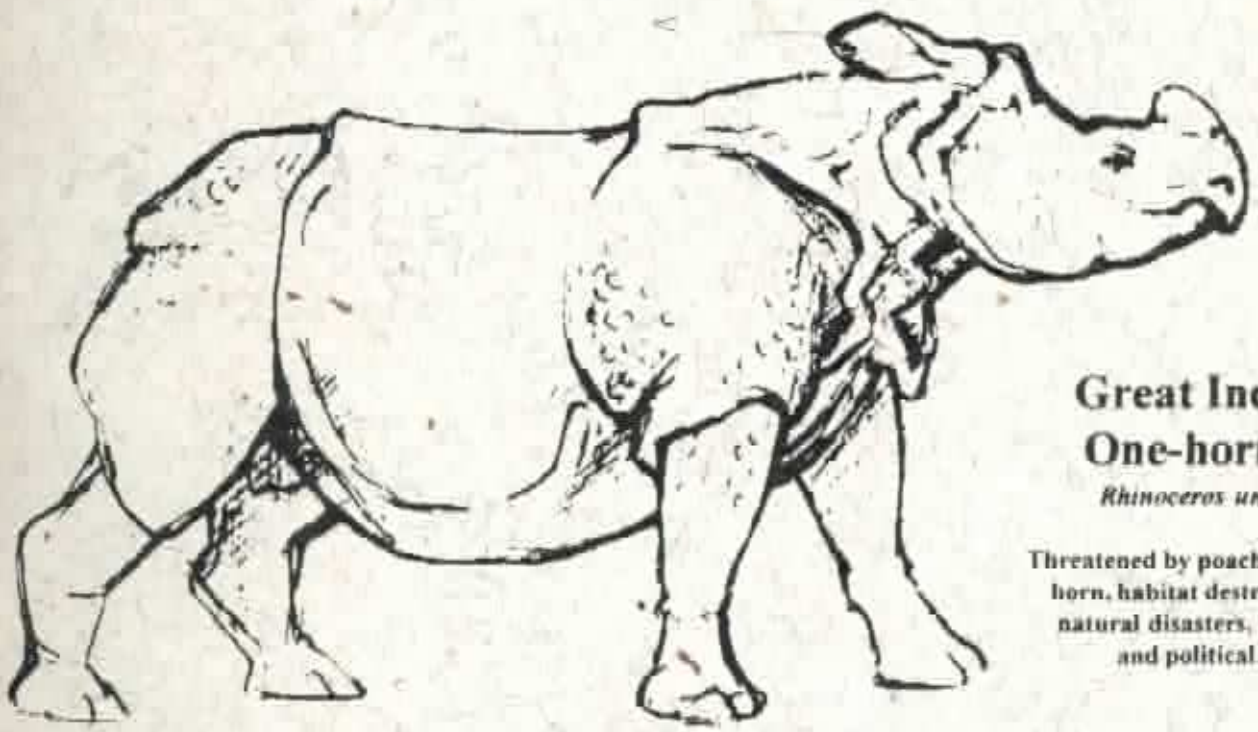
Rhinoceros



Great Indian One-horned,
Rhinoceros unicornis

Threatened by poaching for horn, habitat destruction, natural disasters, public and political apathy

MANUAL FOR CHUTE DESIGN FOR THE RHINOCEROS

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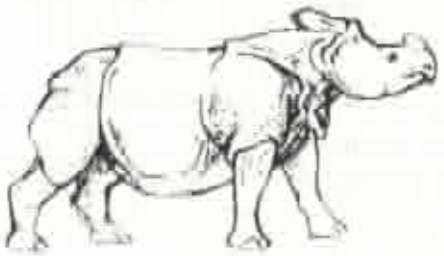

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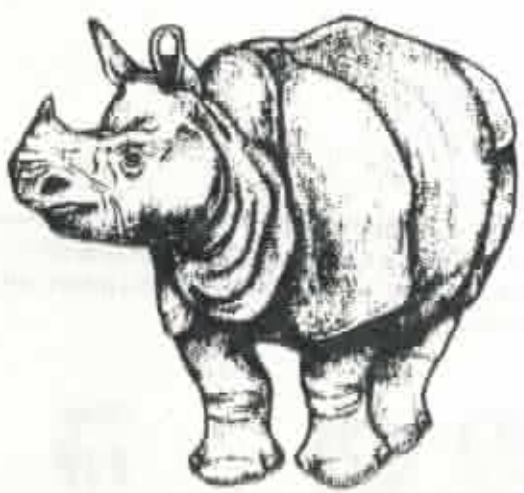

MANUAL FOR CHUTE DESIGN FOR RHINOCEROS

Not all zoos are so lucky as Assam State Zoo, or Patna Zoo or Kanpur Zoo, all of which have produced a somewhat steady stream of rhino calves over the last few years.

Even Kanpur and Patna, whose rhino calf record comes to nearly one per year for some years now have their own reproductive problems. The Kanpur Zoo has produced only male rhino for the last five births and the Patna Zoo, only females. While both sexes are inherently valuable, a predominance or a paucity of either one is not optimal. Research into the reproductive physiology of the species and the individuals is necessary to find out if this is a problem or a cooincidence and if it is a problem how to solve the problem. There are indications that even diet can play a role in sex determination according to some recent research.

Some zoos, such as Nandankanan Zoo have pairs of rhino which live together amicably enough and seem healthy but do not breed, or even if they breed, do not conceive. Reproductive research on these individuals is needed to determine if they are incompatible or unviable or if there is a management problem.

Since rhino births at best come along once in two years for a female and since rhinos are so large and potentially dangerous the study of their reproductive physiology is fraught with difficulties. Attempting to create and maintain a viable population outside the wild is extremely problematical and does not bode well for ex situ conservation programmes.

If a zoo has a pair of rhinos, years can be wasted before it can be concluded that the pair is sexually or reproductively incompatible. Time, energy and funds can be wasted moving these unweildy animals from zoo to zoo, only to find that they are infertile or otherwise unviable.

An understanding of fertility in this species can greatly enhance species management, save time and resources and lead to more and better chances of births. Now rhino fertility can be determined by assessing the quality of semen for males or examining the cycling or pregnancy of females. There are new procedures for collection of semen and examination of female organs with ultrasound which can help in locating problems in and solutions for rhino reproductive ability.

Dr. Nan Schaeffer has been working with rhino reproduction for many years as the Reproductive Physiologist for the Chicago Area zoos and other zoos as well. During the last decade she and veterinary colleagues at several zoos have worked collaboratively to perfect methodology and devices to hold rhinos during examination and procedures. Dr. Schaeffer has trained several rhinos to simply hold still for some semi-invasive procedures but this is not an ideal solution given the size and strength of a rhino and the complexity of some of the procedures.

Dr. Schaeffer has collected some of her articles and designs together with those of others in U. S. zoos which work well and prepared a Manual or compendium on Chute Design. We requested her for a copy of this which we have gone through and retained portions which might be useful and appropriate for Indian conditions. The chute designs and procedures described provide comfort and protection for the animal as well as for the

REPRODUCTIVE PROCEDURES AND RESTRAINT FOR RHINOCEROSES

N.E. Schaffer, D.VM.; R.S. Jeyendran, D.V.M., Ph.D., Northwestern University Medical School, Department of Obstetrics/Gynecology; B. Beehler, D.V.M., Milwaukee County Zoo

Understanding rhinoceros fertility can improve management of the species, particularly of critically limited populations. For example, if fertility of the animal is analyzed first, then effort and expense can be properly spent on treating and moving only the viable animals. Rhinoceros fertility can be determined by assessing the quality of semen of males and the cycling or pregnancy in females. For making these assessments in the rhino, new procedures for semen collection and ultrasound were developed and used to establish normal reproductive parameters. With these procedures and an understanding in reproductive physiology, assisted reproductive techniques such as artificial insemination can be performed to help maintain the genetic balance of small populations.

The increased inter-cooperation of zoos and the recent development of chutes for restraining rhinos for examination has significantly increased sample sizes and the relevance of studies. However, more extensive studies are needed to understand the basic reproductive physiology of the species. This summary proceeds from a new basic chute design for restraint; to brief descriptions of fertility assessment techniques such as ultrasound and semen analysis; and concludes with the preliminary use of assisted reproductive techniques such as semen cryopreservation. The information summarized in this paper was compiled from 10 years of personal observation and the efforts of many individuals and cooperating institutions. The rhino species examined were the black (*Diceros bicornis*), white (*Ceratotherium simum*) and Greater One-horned Asian (*Rhinoceros unicornis*).

RESTRAINT CHUTES

Intensive medical and reproductive examinations of the rhino requires repetitive restraint. Since anesthesia is risky and of limited use for repetitive procedures, chutes were built to restrain these animals. Chute designs at different zoos demonstrate a variety of limitations. Following personal experience with eight chutes with various designs, these authors suggest a design for efficient handling of animals. Although the following description covers major considerations, such variables as available space, animal size, and animal disposition must be individually addressed. Often many variables are not apparent until the chute is in place, therefore, management must be prepared to make modifications.

Since rhinos are similar to elephants in their response to a regular handling regime, daily examination of the rhino is recommended. Therefore, permanent pass-through, indoor chutes are the most convenient. Indoor chutes prevent inclement weather from interfering with studies. The chute should allow restraint of the animal when it is passing through the chute in either direction so the shifting routine of the animal is not interrupted (Fig. 1). Two vertical bars that push in from the sides of the chute to the shoulder of the rhino (Fig. 2), alleviate the excessive forward movement of the rhino when it lowers its head. Quick release of these shoulder bars often relieves agitated animals without having to release them completely. The width of the chute should limit side-to-side movement while still allowing the animal to comfortably lie down. Animals will become wedged in tight fitting chutes if the sides can not be released.

High-walled chutes or bars over the top keep the animals from climbing or rearing up. Horizontal bars, in the chute's entry gates and sides, are hazardous for examiners when the animals lay down. Vertical bars on the sides can trap operator's arms if the animal can move forward. If the animals forward and side-to-side mobility can be limited, vertical bars on all sides are recommended. The distance between these bars along the sides of the chute should be great enough to prevent the animals foot from becoming wedged if the animal rolls on its side in the chute. For examiner safety, this distance should be divided with removable vertical bars.

Since rhinos slam swinging doors, sliding or guillotine gates are the most effective (Fig. 3). A rectangular opening in these gates for performing palpation should not pin the arm of an examiner when the animal is shifting or becoming recumbent. The distance between the vertical sides of this rectangular opening must be wide enough for examiner safety while still limiting the space in which a rhino could squeeze through. Also, the horizontal bottom bar of this rectangle should be

only a few inches from the ground since animals frequently become recumbent. Solid doors on the outside of these gates should be used to stop rhinos, since they will attempt to charge even small openings. Good lighting and electrical sources are useful.

This chute design successfully restrains the male and female white rhino for routine examination, even when they become highly agitated and fractious. Many of the specifications of this improved design were instituted at the Henry Vilas zoo in Madison, Wisconsin. Ultrasound examination of the female revealed that she was non-cycling; etiology and treatment are being pursued. Semen collection techniques are being developed on the male.

FERTILITY

With a basic understanding of the physiology, anatomy and histology of the rhino, comparisons can be made with domestic animals which allows researchers to borrow standard techniques for fertility assessment. These techniques are used to establish normal parameters for rhinos from which abnormalities or pathologies can be determined. Techniques presented here include ultrasound examination of the female reproductive tract and semen collection and analysis from the male.

Ultrasound

Only recently has the normal structure of reproductive organs of the rhinoceros been described. Schaffer and Beehler (1990) provided gross postmortem descriptions and diagrams of both the male and female reproductive tracts in three species of rhinoceros. These reproductive structures were compared with in vivo ultrasound images. Godfrey et al. (1991) gives descriptions of postmortem tracts in the female African rhino.

The male reproductive tract is characteristic of both the stallion and the bull. The accessory glands lie within the pelvic canal and can be imaged with a 5.0 MHz probe. The accessory glands include paired vesicular and bulbourethral glands and a prostate. The testicles in the rhinoceros are extra-abdominal and lie dorsolaterally to the penis in the same skin-fold.

The female anatomical structures compare to both the mare and cow. Distinguishing characteristics include a convoluted cervix with interdigitating folds that appear on ultrasound as dark and light swirls above the dark image of the bladder. A short bifurcated uterine body leads to a bicornate uterus. The uterus lies loosely on top of the intestines and courses cranially toward the kidneys. The

females ovaries lie 70–100 cm from the vulva, therefore, ultrasound probes (principally 5.0 MHz) need to be attached to extensions so that operators can reach the ovaries to image them through the rectal wall.

The ovaries are covered with a thick tunica albuginea and consist of an outer cortex (zona parenchymatosa) and a central medulla (zona vasculosa) similar to those seen in ruminants (Ken Ilio, personal communication). The ovaries are ovals that are flat if quiescent or round during active folliculogenesis. Appearance of corpus luteum on surface of ovaries suggests ovulation occurs from the surface, rather than into a fossa as in the mare. A broad infindibulum with extensive fimbria that covers the entire ovary supports this supposition.

Ultrasound examination has allowed the determination of early pregnancy (Greg Adams, personal communication) and late pregnancy (Schaffer, personal observation) in a black rhino. Follicles and pregnancy corpus luteum have been identified on the ovary. Hormonal assays to monitor cycling of the female could be validated using ultrasound.

Pathological conditions that have been identified in the rhino with ultrasound include ovarian and endometrial tumors and cysts in non-cycling white and black rhinos. Ovarian bursal cysts also occur and must be differentiated from ovarian cysts and follicles. Leiomyofibromas (Montali, see these proceedings), (Griner, 1983) and ovarian fibromas and cysts (George Foley, personal communication) have been identified in older animals at necropsy. Diagnoses and treatment resolutions may be determined with ultrasound examination which would expedite breeding success.

Semen Collection

Semen evaluation provides insight on the fertility status of the male. Ejaculates have been acquired from anesthetized animals with electroejaculation (Platz et al., 1979; Howard et al., 1983) and unanesthetized animals (Young, 1967; Spellmire and Booth, 1981; Schaffer and Beehler, 1988). The first fraction of the first urine voided in the morning by the rhino has often included sperm (Schaffer, personal observation). This provides evidence of sperm production, but not its viability since urine is detrimental to sperm quality. Various techniques of semen collection from a Greater One-horned Asian rhinoceros (such as penile massage, rectal massage, artificial vagina, and rectal probe electroejaculation) were detailed previously (Schaffer et al., 1990).

Most animals required protracted periods of training (1-3 years) before semen samples could be regularly collected. In a few animals semen was collected during initial attempts using penile massage. Collection of semen by penile massage was successful in three black, five white and one Greater One-horned Asian rhino. Rectal massage was successful once in this same Asian rhino. One white, one black and two Asian rhinos ejaculated into artificial vaginas but samples recovered had few to no sperm. Low voltage electroejaculation applied to two black, one white and two Asian rhinos did not induce ejaculation. In one Asian rhino, sperm concentrations increased in fluids from penile massage when this method was preceded by electroejaculation or rectal massage (Schaffer et al., 1990).

Penile massage is the easiest to apply and most widely used method, however, further modification and development of other methods will provide options for collecting semen and may improve the quality of semen samples.

Epididymal sperm is a viable source of gametes for assisted reproductive technologies. Epididymal sperm was obtained from five rhinoceroses (two Asian, two white and one black species) at postmortem.

To obtain epididymal sperm an incision should be made along the lateral side of the base of the penile sheath to allow removal of the testicle surrounded by it's parietal vaginal tunic. To remove semen from the epididymis different techniques were used for the African and Asian species, since the morphology of the epididymis of each was significantly different. The tubules in the African species were so small and densely packed that the tail had to be chopped and the tissue rinsed to recover semen. Only a few (1-2 ml) were recovered. In the Asian rhino, the tail of the epididymis was round, firm and bulbous, protruding from the distal pole of the testicle. The lumen of the tubules were large, allowing semen (total 18.7 ml and 25.0 ml) to be easily removed by squeezing the tissue after puncturing the tail with a 16 gauge needle several times or slicing through it once. Sperm counts from the epididymis were: black rhino, 8.9×10^8/ml; white rhino, 1.3×10^7/ml and 12.3×10^8/ml; Asian rhino, 6.5×10^{10}/ml and 85.3×10^8/ml.

Semen Analysis

Normal seminal parameters of rhinos were presented by Schaffer and Beehler (1988). These parameters have been updated in Table 1. Since many zoos are in the process of handling rhinos for semen collection, knowledge about the quality of initial semen samples is useful to evaluate the progress of training.

For comparison, initial semen samples were collected by manual massage of the penis from ambulatory rhinos, including three black, six white and two Greater One-horned Asian rhinos. Ejaculates were examined for color, consistency, volume, sperm count, sperm motility, pH, sperm morphology, cytology and sediment. Most of the 1–30 initial samples in all three species were of poor quality and had common characteristics. These samples were primarily dribbles of thin, white, brown or yellow translucent to opaque fluid. The pH was 7.5–9.0; volumes were 0.1–5.0 ml. Although in a few of these individuals, the first attempt at collecting semen resulted in a sample with several million sperm, often, subsequent samples had few to no sperm. Several million per ml epithelial and white blood cells could occur particularly in smaller sample volumes. Sediment was extensive, consisting of calcium carbonate crystals and cells. The sediment was white and sometimes flocculent due to strands of mucus with trapped cells and crystals.

Later samples from individuals varied between species. In three of the white rhinos collected approximately every 1–2 weeks for 1–2 years, samples have not changed remarkably from initial quality mentioned above. Sperm count ranged from 0.01×10^6–32.0×10^6. After the first few (1–5) semen samples in one 39-year-old black rhino (Spellmire and Booth, 1981) and one Asian rhino (Schaffer et al., 1989), the samples became clear to cloudy white and thicker in consistency, with total volumes of 0.5–150.0 ml. Sperm concentrations were 0.2×10^6/ml–5.0×10^9/ml, and motility 0-90%. These samples had a pH of 7.0–8.5, and contained few to no cells or crystals. These ejaculates were produced in drips or squirts of fluid. In the black rhino, sampling continued several times a year for 10 years. Samples remained consistent except for a recent lowering of sperm count.

In the Asian rhino, after four years of semen collection approximately twice a month, samples (30th to 68th) in the fourth year became primarily white in color with volumes of 0.2–15.0 ml. Sperm concentrations were 1.8–20.2×10^9/ml, motilities were 0–50%, pH 6.5–8.0, and they contained very little sediment.

Sperm abnormalities in all the samples were similar within all three species. The abnormalities were primarily, neck and mid-piece cytoplasmic droplets; bent, kinked or folded mid-pieces; coiled tails; and detached heads. Some variation in head size and abaxial tail attachment to the head was also seen.

Table 1. Ranges of Seminal Parameters of Ambulatory Rhinoceroses Collected by Penile Massage

SPECIES	VOLUME	SPERM		
		Concentration	Motility	Abnormality
	(ml)	($x\ 10^6$/ml)	(%)	(%)
Black (n=3)	0.2–164.5	0.0–600.0	0–90	40.0–90.0
White (n=6)	0.2–8.0	0.0–32.0	0–20	20.0–86.0
Asian (n=1)	0.1–500.0	0.0–20,000.0	0–95	5.0–92.0

Although fertility/infertility cannot be differentiated among these samples, the above characteristics (volume, sperm concentration and motility and sediment), may be used for comparison as semen collection progresses.

ASSISTED REPRODUCTION

Although artificial insemination and embryo transfer are desirable for reproductive management of rhinos, further development of techniques is necessary. Equipment needs development for dealing with the complicated cervix and lengthy uterus of the female. Detailed identification of events in the female reproductive cycle will aid in the development of ovarian stimulation and estrus synchronization regimens, as well as timing for artificial insemination. In addition, effective collection and preservation of gametes needs to be developed. These obstacles can be overcome with dedicated commitment by zoological institutions. The resulting protocols would then be readily applicable to rhinos already acclimated to routine handling.

Cryopreservation

Cryopreservation of semen of the black rhinoceros using one type of extender resulted in successful recovery of post-thaw sperm motility (Platz et al., 1979; Spellmire and Booth, 1981). Only one type of extender was used in these studies and motility recovery was less than 50%. Different extenders may improve recovery of sperm viability.

Ten different milk and egg yolk extenders with 4% and 7% glycerol were applied to the split ejaculates of a 30-year-old Greater One-horned Asian rhinoceros.

Only similar ejaculates "sperm-rich fractions" (1.5–13.8 x 10^9; 30–60% motility) which were low in accessory gland fluid were used to cryopreserve with the "pellet" method. Extenders were ranked according to the results of sperm motility, exclusion of eosin dye staining, and sperm responds to hypoosmotic swelling. Significant differences were not demonstrated between milk and egg extenders, however, viability improved in all extenders containing less glycerol (4%). This study suggested that this rhino's sperm was sensitive to glycerol. This may have also been a factor in low recovery of sperm of a black rhino which was frozen in 9% glycerol (Spellmire and Booth, 1981).

CONCLUSION

These procedures are applicable to zoological institutions and can be used to establish parameters that will help to qualify the fertility of the population. Regular monitoring of the health and reproductive status of the rhinoceros would significantly improve their management. This insight can be gained with minimum expense in cage modification and efforts by personnel. Once the fertility of the animal has been determined, reproductive management strategies can be developed to help preserve genetic variability in the rhino population.

ACKNOWLEDGEMENTS

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For assistance in the acquisition of samples: the Audubon Park Zoo; Lee Bass, El Coyote Ranch; Calvin Bentsen, La Coma Ranch; Busch Gardens; Cheyenne Mountain Zoo; Dallas Zoo; Denver Zoo; Kings Dominion; King's Island Wild Animal Habitat; Memphis Zoo; Metro Miami Zoo and Toledo Zoo.

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For providing cryopreservation media: Mary Densmore, Roger Hanson, Landmark Genetics, Steve Magyar, and American Breeder Service.

For ultrasound equipment: Chuck Boland and Jim Chrzan of Corometrics Medical Systems.

For technical and editorial assistance: Julie A. Kreiner.

Videos on semen collection techniques and chutes or ultrasound techniques are available from Dr. Nan Schaffer, Northwestern University Medical School, Dept. of Obstetrics and Gynecology, Prentice 1504, 333 E. Superior Street, Chicago, IL 60611-3095, U.S.A., (312) 908-0902/FAX: (312) 908-6643.

REFERENCES

Godfrey R.W.; Pope C.E., Dresser B.L., Olsen J.H. Gross anatomy of the reproductive tract of female black (*Diceros bicornis michali*) and white rhinoceros (*Ceratotherium simum simum*). ZOO BIOLOGY 10:165-175, 1991

Griner, L.A. Pp 487 in PATHOLOGY OF ZOO ANIMALS. Zoological Society of San Diego, San Diego, California, 1983.

Howard J.G.; Bush M.; Collby L.; de Vos V.; Wildt D.E. Electroejaculation techniques and semen evaluation in rhinoceroses. AMERICAN ASSOCIATION OF ZOO VETERINARIANS ANNUAL CONFERENCE PROCEEDINGS, Abstracts, Tampa, Florida. pp 74-75, 1983.

Platz C., Seager S.W.J.; Bush M. Collection and ânalysis of semen from a black rhinoceros. JOURNAL OF THE AMERICAN VETERINARIAN MEDICAL ASSOCIATION 175:9, 1002-4, 1979.

Schaffer N.E.; Beehler B. Overview of procedures and results of semen collection from ambulatory rhinoceroses. AMERICAN ASSOCIATION OF ZOOLOGICAL PARKS AND AQUARIUMS ANNUAL CONFERENCE PROCEEDINGS, Milwaukee, Wisconsin. pp 273-279, 1988.

Schaffer N.; Beehler B. Preliminary studies on the anatomy and ultrasonic images of the reproductive structures of three species of rhinoceroses (*Rhinoceros unicornis, Diceros bicornis, Ceratotherium simum*). AMERICAN ASSOCIATION OF ZOO VETERINARIANS PROCEEDINGS, pp 215-220, 1990.

Schaffer N.E.; Beehler B.; Jeyendran R.S., Balke B. Methods of semen collection in an ambulatory Greater One-Horned rhinoceros (*Rhinoceros unicornis*). ZOO BIOLOGY 9:211-221, 1990.

Spellmire T.J., Booth B.H.. Artificial breeding program for Diceros bicornis, the black rhinoceros. AMERICAN ASSOCIATION OF ZOOLOGICAL PARKS AND AQUARIUMS REGIONAL CONFERENCE PROCEEDINGS, Peoria, Illinois, pp 296-301, 1981.

Young E. Semen extraction by manipulation technique in the black rhinoceros. INTERNATIONAL ZOO YEARBOOK 7:166-167, 1967.

General Notes & Operating Instructions

for the St. Louis Zoo Rhino Restraint Chute

The proposed Rhino restraint chute is fabricated from 6061-T52 aluminum.

First, for the weight and maneuverability, and secondly to eliminate the clanging of steel against steel, which seems to upset the rhinos. Aluminum has a deader ring to it.

I have been assured by Reynold Aluminum that 6061-T52 aluminum has the same strength as steel, and also the same deflection properties.

Each side of the chute will weigh approximately 300 lbs. It will be hinged off of a six (6) inch steel pipe set three (3) feet into concrete.

Each side of the chute will be hinged in the center to allow it to fold against itself, and then swing against the existing fence. This will allow the gangway to be used as an access for trucks and equipment.

On the opposite end of the chute will be 5" x 16.0 wide flange beams, which will act as a locking support.

After the chute is locked in place, (3) 5/8 bolts and nuts are installed at the center hinge, through both uprights as a safety feature.

Next the eight (8) screwjacks are screwed down. They will have a large washer or plate welded in place approximately three (3) inches from the bottom. This will bear on the ground to help support the weight of the chute. The three (3) inches below the washer will insert into pipe sleeves set in concrete in the ground. This will add strength to the sideway motion of the chute.

The framework for the guillotine gate is a four (4) inch x 2-1/4 inch channel. This acts as a track for the gate.

The top and bottom runners on the chute will be drilled on six (6) inch increments to allow as tight a fit against the rhino's rump as is possible.

The rhino must be conditioned to feed at the sliding gate from a removable feeder.

An additional guillotine gate or similar device will be designed to drop into place to harness the rhino's shoulders. It will be designed to allow the rhino to escape into the yard in the event of an emergency, yet be completely safe for the keepers or other personnel.

The framework for the guillotine gate will weight approximately sixty (6) pounds and can easily be put in place by two (2) men.

The gate itself will only weigh approximately fifty-five (55) pounds, so it can be raised and lowered by one man.

The location of the guillotine gates can be pre-determined visually while the rhino is being oriented.

Once the rhino has his head through the shoulder restraint gate, he can not raise up, due to the top horizontal runner on the gate.

There are no intermediate runners for the rhino's to climb on or for a technician's arm to catch on should the rhino suddenly drop while being treated.

There are no swinging gates or other moving parts that must be operated in order to get the animal in position.

If, for some reason, there is too much side movement in the chute, braces connecting both sides could easily be bolted across, since there would be approximately eighty-six (86) inches clearance from the ground.

See the drawing for material sizes and fabricating techniques.

Ron Tullock

RON TULLOCK
Supervisor, Maintenance

RT:dd

CHUTE DESIGN TO RESTRAIN AMBULATORY RHINOCEROSES AND REPRODUCTIVE EXAMINATION

N. Schaffer, D.V.M., Lincoln Park Zoo; D. Hall, D.V.M., Henry Vilas Zoo; B. Beehler, D.V.M., Milwaukee County Zoo

With training, rhinoceroses can become tractable subjects for reproductive investigation. To expedite training, zoos have built chutes to restrain their animals. Diverse chute designs were built at seven different zoos. Highly agitated and fractious animals have been successfully restrained in the most recently designed models, particularly one at the Henry Vilas Zoo; however, these designs still have their limitations. This report identifies major problems with chutes and makes suggestions for improvements in design.

In an improved design for rhinos, the chute is twice the length of the animal's shoulder to rump measurement and is divided with two vertical bars that slide in from the sides of the chute to the shoulder of the rhino. When the rhino lowers its head, it can move forward in a chute as much as two feet. The bars alleviate this excessive forward movement. In addition, this allows the animal to be stopped and handled going either way in the chute. Being able to quickly release these bars often relieves agitated animals without having to release them completely. Tall chutes or bars over the top keep the animals from climbing or rearing up. Horizontal bars, in the chute's gates and sides, are hazardous for examiners when the animals lay down. If the animals forward and side-to-side mobility is limited, vertical bars on all sides are recommended. The distance between these bars along the sides of the chute should be greater than the width of the animals foot, which will keep a foot from becoming wedged if the animal rolls on its side in the chute. For examiner safety, this distance is divided with removable vertical bars. Since rhinos slam swinging doors, sliding or guillotine gates are the most effective. A rectangular opening in these gates for performing palpation should not pin the arm of an examiner when the animal is shifting or becoming recumbent. The distance between the vertical sides of this rectangle must be wide enough for examiner safety while still limiting the space in which a rhino could squeeze through. Also for operator safety, since rhinos lay down in their chutes, the horizontal bottom bar of this rectangle should be only a few inches from the ground. Solid doors should be used to stop rhinos, since they will attempt to charge small openings.

Rhinos are trained daily; therefore permanent, indoor-to-indoor, pass through chutes are the most convenient. This also prevents inclement weather from interfering with studies on the animals. Good lighting and electrical sources are useful. Consideration of these modifications when constructing these chutes will improve safety when examining the rhinoceros.

RHINO CHUTE (side)

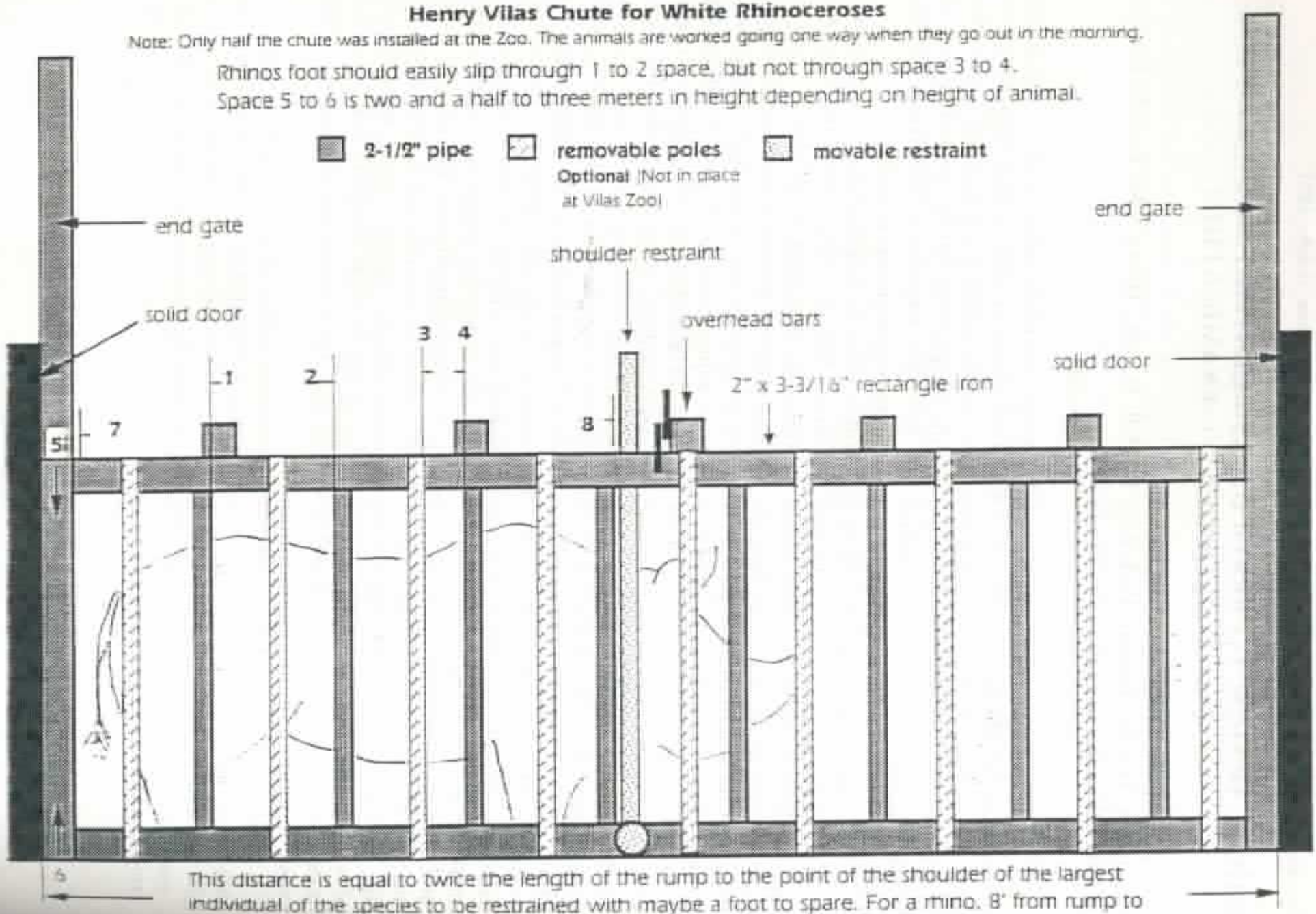
Henry Vilas Chute for White Rhinoceroses

Note: Only half the chute was installed at the Zoo. The animals are worked going one way when they go out in the morning.

Rhinos foot should easily slip through 1 to 2 space, but not through space 3 to 4.
Space 5 to 6 is two and a half to three meters in height depending on height of animal.

2-1/2" pipe **removable poles** **movable restraint**

Optional (Not in place at Vilas Zoo)



This distance is equal to twice the length of the rump to the point of the shoulder of the largest individual of the species to be restrained with maybe a foot to spare. For a rhino, 8' from rump to point of shoulder.

Measurements: 7–8=9"; 1–2=1-1/4"; 3–4=6"

RHINO SIZE:

- point of hip to point (3'2"):
  Width at shoulders = 2'
- rump to point of shoulder = 8'
- length of rhino varies from 9' (head down) to 10'8" (head up)

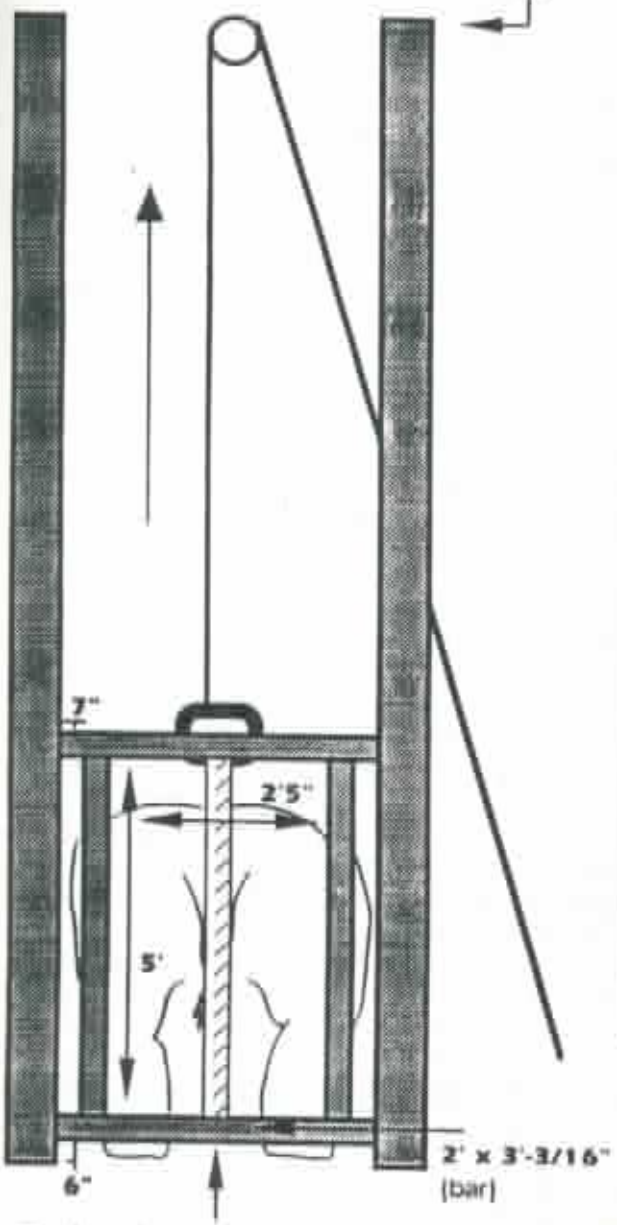
END GATE

(front and back gate)

2-1/2" pipes

Removable poles (Optional)

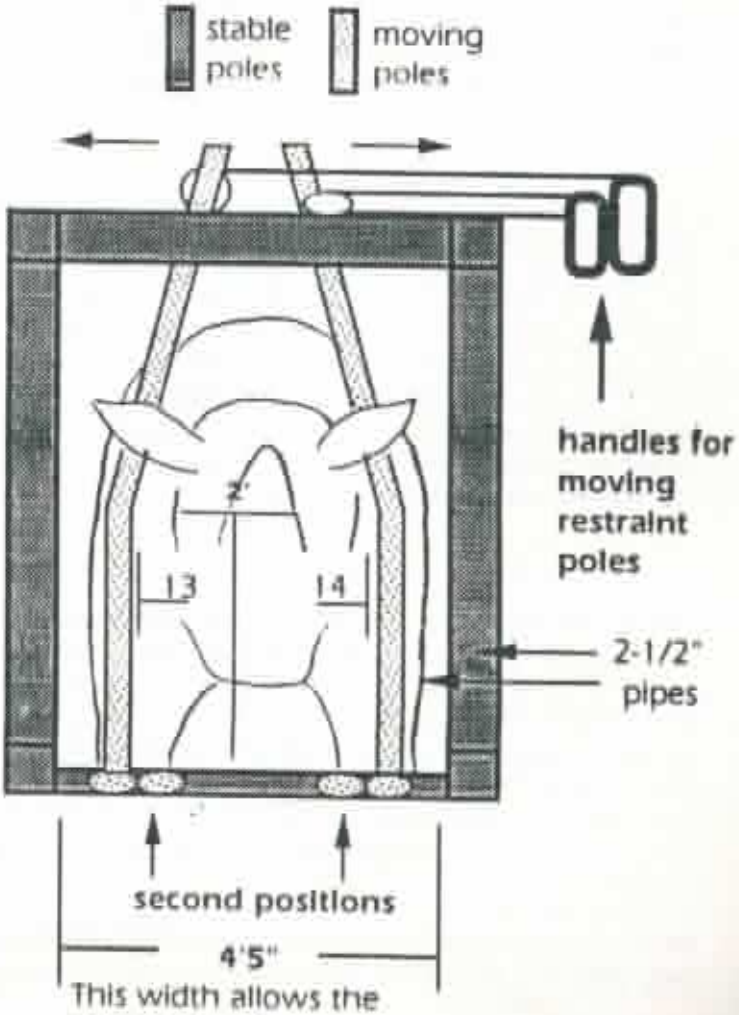
Track 3-1/2" x 3-1/2" angle iron x one pipe of 3-1/2" flat welded on side.



Optional center bar, but if not present, measurements must be exact.

SHOULDER RESTRAINT

Space 13 to 14 (measure. 2'2") opens to allow rhino through. This space can be narrowed by adjusting shoulder restraint bars to second position.



This width allows the rhino to lie down comfortably.

CASE REPORT: SUCCESSFUL BIRTH AFTER INTENSIVE MANAGEMENT OF AN AGED BLACK RHINOCEROS (Diceros bicornis) WITH A HISTORY OF ABORTIONS

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History

Following two live births, 15 years of non-breeding, and three recent spontaneous abortions, a wild-born (1962 est.) female black rhinoceros (SB#53) at the Sedgwick County Zoo delivered a healthy male calf on August 16, 1993. According to 1992 Black Rhinoceros Studbook records, she is the oldest female to have produced an offspring in captivity, and is one of the few animals to produce after repetitive abortions. Aggressive health and dietary management, along with supplemental progesterone is believed to have assisted in maintenance of this 470-day pregnancy. Since arriving in Wichita in 1988 on breeding loan from the Detroit Zoo, she had bred regularly to a male (SB#301) but aborted fetuses at 8 months (Oct. 1989), 10 months (April 1991), and 4 months (December 1991). Trauma to the female in one case, and placentitis in the last two cases were suspected of contributing to the abortions. After each abortion, the female was allowed several months of recovery and then usually became pregnant immediately after reintroduction to the male as determined by non-return to estrous and salivary hormone assay (Czekala, pers. comm.). In March of 1992, when the female was expected to become pregnant again, close monitoring of medical and reproductive status was begun to try to elucidate the causes of reproductive failure.

Diet

The female rhinocerosceros had fluctuated in weight since arriving at the zoo. Therefore, the caloric and vitamin/mineral content of the diet was increased significantly. During the last pregnancy she was fed daily: 12 pounds ADF 16% herbivore pellets (Purina Mills, Richmond, IN), 3 pounds elephant supplement (Purina Mills, Richmond, IN), 12-16 oz of molasses, 1/2 cup of trace mineral salt (Morton Co., Hutchins, KS), 1 carrot, 1 onion, 1 celery stalk, 20 lbs. 1:2 prairie hay/alfalfa, 10 pounds alfalfa cubes and 30cc (vitamin E) of TPGS (Mazuri, Purina Mills, Richmond, IN). At mid-pregnancy, when boluses of half-chewed hay revealed she was having difficulty in chewing, the diet was divided into four feedings. Also, the prairie hay/alfalfa was shredded. In addition, 3 pounds/daily of dairy chow (Purina Mills, Richmond, IN) were given during the third trimester. She experienced severe weight loss during the first half of pregnancy. During the last half of pregnancy, her weight and conditioning improved significantly.

Restraint

Closer monitoring of the female's health and reproduction was possible through the use of a restraint chute. This chute is patterned after the Henry Vilas Zoo design and constructed of aluminum vertical bars (J&M Construction, Wichita, KS). It folds into place in the off-exhibit passage between indoor and outdoor exhibit areas. The endgates are guillotine backed by solid doors. This chute is long and flares at either end to make it flush with the exhibit gates. This flare allows the animals to swing their rumps from side-to-side. Interim guillotine gate eliminates the flare, but shortens the chute making it difficult to close the gate before the animal backs up. This female black rhinocerosceros allowed, almost immediately, cephalic vein blood collection and ultrasonography.

Medical Management

Medical treatments were performed as indicated by weekly analysis of hematology and serum chemistries. These values remained unremarkable throughout pregnancy except for a slightly low

phosphorous (3.1–4.9 mg/dl) which caused a slight imbalance in the calcium to phosphorous ratio. Also, low glucose levels (19–40 mg/dl) were treated by daily administration of molasses. The frequent appearance of mucopurulent vaginal discharges were treated by flushing the vagina with Nolvasan uterus suspension (Ft. Dodge Laboratory, Ft. Dodge, IA). An acute case of anorexia and depression in the female resolved after treating a toe abscess. Periodic skin ulcerations were controlled by a topical ointment, Nolvasan, massaged into the skin. She periodically had bouts of diarrhea. Since sand impaction had occurred in the male, Equisyl (Animal Health Care Products) or mineral oil was administered in the female's diet.

Reproductive Management

Ultrasonography (3.5 MHz and 5.0 MHz linear probe and 500 Aloka scanner: Corometrics, Wallingford, CT) was performed once a week for 2 weeks before conception and during the first 12 weeks of pregnancy. A dominant follicle was associated with estrous. A persistent cyst (30mm) was associated with the right ovary. Follicular development continued during the first 12 weeks of pregnancy. A 28x23mm corpus luteum was noted on Day 38 of pregnancy. On Day 16 of pregnancy, a 20x22mm vesicle was noted in the uterus. After Day 25 the vesicle was undetected until Day 50 when the membranes of the dorsal embryonic sac began to reappear.

Serum was collected at least every other week for 70 days prior to conception and throughout pregnancy from the right or left cephalic vein. Feces and urine were collected at least once or twice a week. Serum progesterone was analyzed during pregnancy by radioimmunoassay by Roche Biomedical Laboratories (Fig. 1). Steroid hormones and conjugates were also analyzed in urine, feces, and serum with enzyme immunoassay (Berkeley and Schaffer, 1992) (Fig. 2). Serum progesterone radioimmunoassay analyzed during the estrous cycle reached nadirs of <0.2 ng/ml and peaks averaging 15 ng/ml. During the first five to six months of pregnancy, values ranged from 1.2–9.8 ng/ml. After six months the values ranged from 10.1–35.7 ng/ml with an average of 19.3 ng/ml. The patterns for serum progesterone radioimmunoassay compared closely with levels resulting from enzyme immunoassay analyses. However, the fecal progesterone levels during the last 10 months of pregnancy demonstrated a 5–10 fold increase from luteal phase levels (pregnancy: 3000–4000 ng/g dry feces; luteal phase 300–800 ng/g dry feces).

DISCUSSION

Restraint

At least nine different chutes have been built for four species of rhinoceros (Schaffer et al. 1991). The chute at Sedgwick was built according to a chute designed by the primary author at the Henry Vilas Zoo in Madison, Wisconsin. All exams or treatments were performed in this chute alleviating the need for anesthesia. Anesthesia has contributed to or been the cause of death in at least three species of rhinoceroses. Although the expense is greater and the training is more time-consuming, the use of chutes has allowed repetitive performance of a variety of procedures in four species of rhinoceros, including blood collection, ultrasonography, semen collection, bladder catheterization, and skin and foot treatments. In some instances, operators have trained rhinoceroses to tolerate ear and cephalic vein blood collection without restraint by offering food and contact (D. Nichols, pers. comm. and M. Illig pers. comm.). While this training has provided some medical and reproductive monitoring for several months, it would have limited usefulness if the animals require intensive medical or reproductive treatment.

Monitoring and Management

Ultrasonography has been shown to be a safe method for assessment of estrous cycling, pregnancy, and pathology in the rhinoceros (Adams et al. 1992; Schaffer et al. 1992; Schaffer et al. 1991; Schaffer and Beehler 1990). Since this method has proven to be useful for identifying reproductive status in the black rhinoceros, it was used to validate circulating and excreted hormone levels. The same correlations between ultrasonographic images and hormone levels normally seen in the domestic animal were also seen in the rhinoceros. The dominant follicle was associated with decreasing progesterone levels and increasing estrogen levels. A regressing corpus luteum was associated

with decreasing progesterone levels. A pregnancy vesicle was consistent with persistent progesterone levels, however, the vesicle lost shape and dropped beyond probe penetration within 25 days, making it difficult to monitor the embryo. The dorsal vesicle reappeared after 50 days. The vesicle seemed to drop rapidly which may have been due to the age and lasity of this female's reproductive tract.

Circulating or excreted hormones have been examined in many animal species including the rhinoceros (Kirkpatrick et al. 1993; Schwarzenberger et al. 1993; Hindle et al. 1992; Lasley and Kirkpatrick 1991; Ramsay et al. 1987; Loskutoff et al. 1982; Kassam and Lasley 1981). In this female,, the monitoring of pregnancy by circulating (serum) hormones could be compared with excreted hormones. Both demonstrated persistent progesterone levels that were lower in the first 5-6 months than in the last 10 months. Both could be used to diagnose pregnancy. However, since the circulating peak levels of luteal progesterone (15ng/ml) compare closely with the pregnancy levels (19ng/ml), these levels can not be used to diagnosis pregnancy. Rather the persistence of increased serum progesterone levels would be indicative of pregnancy. Therefore, serial blood samples over a known estrous cycle duration would have to be analyzed. Alternatively, since the excretory hormone demonstrates a 5-10 fold increase, this high level of progesterone would be indicative of pregnancy. Thus fewer fecal samples are needed to indicate pregnancy and they are easier to acquire. These factors have resulted in the rapid, accurate diagnosis of pregnancy in several animals (Berkeley et al., 1993; Berkeley, unpublished data). The administration of the synthetic progestin may have complicated the excretory hormone analysis. However, this may be disregarded because: 1) the elevation in progesterone in the feces of this female began a month after the beginning of administration of the drug; and 2) the same peak progesterone values have occurred in other pregnant rhinoceroses.

An etiology for abortion in this female was not identified, particularly since pregnancy was successful. Abortion or re-absorption of the fetus occurs more frequently in older domestic animals, however, stress, poor nutrition, and ascending tract infection have also been implicated in other animals and could have been factors in this female.

Although this female was well over the reproductive age (25 years) of rhinoceroses in captivity, she was younger than the reported productive age (35 years) in the wild (Smith and Read 1992). Several problems were addressed that could have been sequela to her age. Her teeth were unevenly worn interfering with mastication. Shredding her food and increasing the numbers of feedings from one to four times a day probably improved her metabolism. On later examination her cervix was found to lack normal tone and closure. This could result in ascending tract infections which were evident in her history of placentitis. In this female, a vaginal discharge was not uncommon, however, when it became copious or discolored during pregnancy it was immediately treated. In addition, the vulva would sometimes become swollen and tender.

A vaginal discharge can often occur in both cycling and pregnant rhinoceroses, particularly in the last few weeks before parturition. The discharge is usually a few drops to a few milliliters of pasty or mucoid material that can accumulate on the tail or vulva. However, one young female black rhinoceros at the Riverbanks Zoo frequently discharged large amounts, up to 250 cc, of material that sometimes formed a large mucoid plug. Investigators have tried associating this discharge in the rhinoceros with estrous, however, since estrous detection is still minimally successful this remains unclear and still needs further characterization.

During the early part of this female's pregnancy, luteal insufficiency became a concern as the cause of abortion. Luteal insufficiency can be a cause of reproductive failure in older animals and can be characterized by early abortion and low serum progesterone. This female's last abortion had occurred early in pregnancy and her serum progesterone was not increasing at the time. Since progesterone is not known to interfere with pregnancy, supplementation was instituted. Recently pregnancy was maintained in another rhinoceros with a history of abortion when progestin was supplemented (B. Durrant pers. comm.).

Nutritional effects on pregnancy can result from over- or under-consumption or imbalances. Black rhinoceroses may have some peculiar nutritional requirements which is still being debated (E. Dierenfeld pers. comm.). Since this rhinoceros had a tendency to lose weight during pregnancy, she was offered a higher vitamin/mineral and caloric diet. Her mineral supplementation was higher than that recommended for a perissodactylid. Her weight loss may have been the greater demand by the fetus on this older female's metabolism. This was indicated since she improved after the hay was shredded and numbers of feedings increased.

Serum chemistries revealed low glucose and phosphorous levels. The low glucose could not be associated with anorexia or pancreatic insufficiencies, but increasing her feedings to four times a day resulted in maintenance of higher glucose levels. The low phosphorous may have resulted from periodic bouts of diarrhea, since the levels improved after resolution of the diarrhea. The causes of these levels remains unclear. Both can be associated with loss of pregnancy. Diabetics are known to have trouble maintaining pregnancy. Calcium-phosphorous ratios can be critical in pregnancy due to the demands of the growing fetus. The phosphorous was only minimally low and, therefore, was not treated. Phosphorous imbalances have been noted in other black rhinoceroses and is being investigated (E. Miller pers. comm.).

CONCLUSION

Intensive management and treatment improved this female's health as well as apparently resolved this animal's reproductive problem. Since 20% of the animals in the 1986 AAZPA Black Rhinoceros Survey had aborted and as of the 1992 Black Rhinoceros Studbook, 17 females were non-producing, this problem, may need further investigation. The etiology of abortion in this female is still unknown but potential problems were identified and treated. This pregnancy can be used as a reference in investigating other aborting females.

REFERENCES

Adams, G.P.; Plotka, E.D.; Asa, C.S.; Ginther, O.J. 1991. Feasibility of characterizing reproductive events in large non domestic species by transrectal ultrasonic imaging. Zoo Biology. 10:247-259.

Berkeley, E.V.; Kirkpatrick, J.F.; Bryant, W.M. Determination of pregnancy, ovulation, and the onset of parturition in the black rhino by using fecal steroid analysis. In: Proceedings of the 1993 Conference of the American Association of Zoological Parks and Aquariums, Omaha, Nebraska, p. 260.

Berkeley, E.V.; Schaffer, N.E. Serum, urinary, and fecal steroid correlates of reproductive behavior in the black rhinoceros (*Diceros bicornis*). In: Proceedings of the 1992 Conference of the American Association of Zoological Parks and Aquariums, Toronto, Canada, p. 572.

Hindle, J.E.; Mostl, E.; Hodges, J.K. 1992. Measurement of urinary oestrogens and 20α-dihydroprogesterone during ovarian cycles of black (*Diceros bicornis*) and white (*Ceratotherium simum*) rhinoceroses. Journal of Reproductive Fertility. 94:237-49.

Kassam, A.A.H.; Lasley, B.L. 1981. Estrogen excretory patterns in the Indian rhinoceros (*Rhinoceros unicornis*), determined by simplified urinary analysis. American Journal of Veterinary Research. 42(2):251-255.

Kirkpatrick, J.F.; Lasley, B.L.; Shideler, S.E.; Roser, J.F.; Turner, J.W. 1993. Non instrumented field tests for pregnancy detection in free-roaming feral horses. Journal of Wildlife Management. 57(1):168-73.

Lasley, B.L.; Kirkpatrick, J.F. 1991. Monitoring Ovarian Function in Captive and Free-ranging Wildlife by Means of Urinary and Fecal Steroids. Journal of Zoo Wildlife Medicine. 22(1):23-31.

Loskutoff, N.M.; Ott, J.E.; Lasley, B.L. 1982. Urinary steroid evaluations to monitor ovarian function in exotic ungulates: I. Pregnanediol-3-glucuronide immunoreactivity in the okapi (*Okapia johnstoni*). Zoo Biology. 1:45-53.

Schaffer, N.E.; Zainal-Zahari, Z.; Mohd. Tajuddin A.; Jainudeen, M.R.; Jeyendran, R.S. 1992. Fertility analysis techniques in the Sumatran rhinoceros (Dicerorhinus sumatrensis): Semen collection and ultrasound. Proceedings Of The American Association of Zoological Parks and Aquariums Annual Conference, Abstract, Toronto, Canada. p. 573

Schaffer, N.E.; Jeyendran, R.S.; Beehler, B. 1991. Reproductive procedures and restraint for the rhinoceros. Proceedings of the International Rhino Conference, San Diego, California. pp. 153-159

Schaffer, N.; Beehler, B. 1990. Preliminary studies on the anatomy and ultrasonic images of the reproductive structures of three species of rhinoceroses (*Rhinoceros unicornis, Diceros bicornis, Ceratotherium simum*). American Association of Zoo Veterinarians Proceedings. pp. 215-220

Smith, R.L.; Read, B. 1992. Management parameters affecting the reproductive potential of captive, female black rhinoceros, *Diceros bicornis*. Zoo Biology. 11:375-83.

Ramsay, E.C.; Kasman, L.H.; Lasley, B.L. 1987. Urinary steroid evaluations to monitor ovarian function in exotic ungulates: V. Estrogen and pregnanediol-3-glucuronide excretion in the black rhinoceros (*Diceros bicornis*). Zoo Biology. 6:275-282.

Schwarzenberger, F.; Francke, R.; Goltenboth, R. 1993. Concentrations of faecal immunoreactive progestagen metabolites during the oestrous cycle and pregnancy in the black rhinoceros (*Diceros bicornis michaeli*). Journal of Reproductive Fertility. 98:285-91

Acknowledgments

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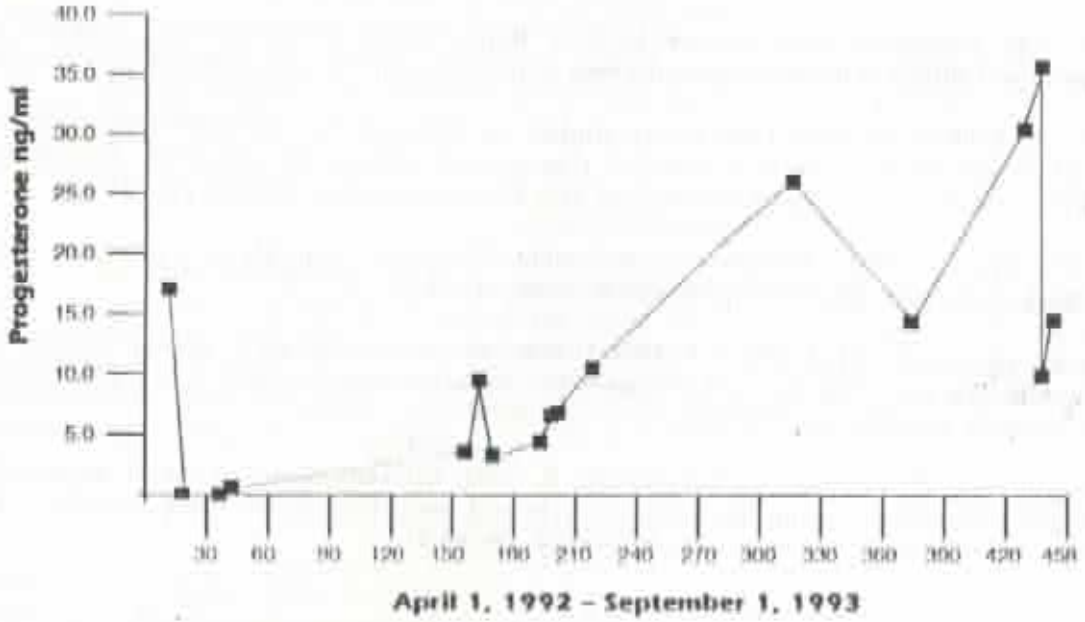


Figure 1. A Comparison of Serum Concentrations During the Estrous Cycle and Pregnancy from the Black Rhinoceros "Bibi" (SB#53). Roche Biomedical Laboratories, 1992.

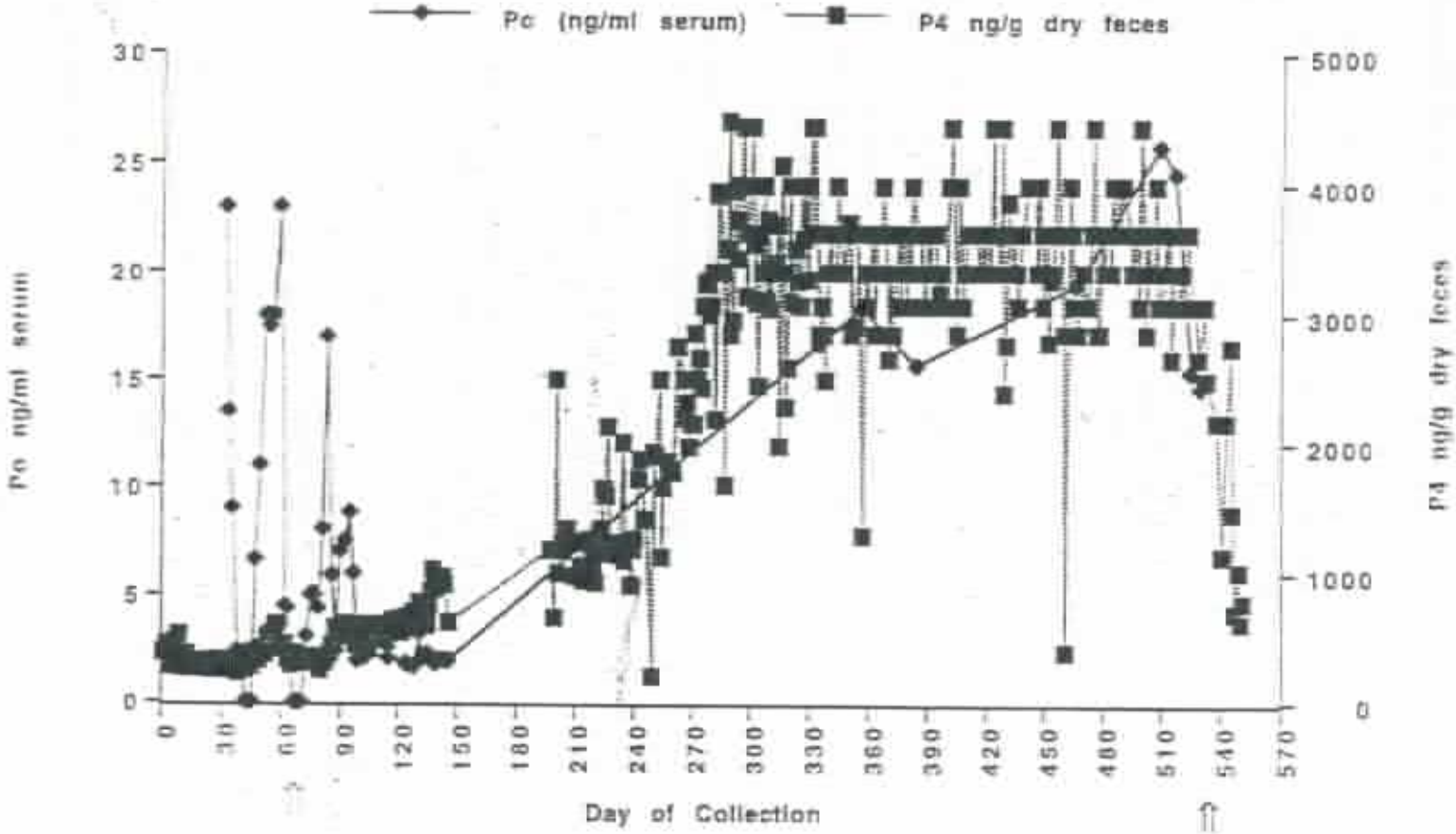


Figure 2. A Comparison of Serum and Fecal Progesterone Concentrations During the Estrous Cycle and Pregnancy from the Black Rhinoceros "Bibi" (SB#53). Reprint from: Berkeley, E.V. Fecal steroid hormone analysis of ovulation and pregnancy in the black rhinoceros (Diceros bicornis). Ohio State University, Thesis, 1994.

These are the chutes that I am aware exist in the U.S., Malaysia, and Indonesia. I have worked with animals in most of them, and all of these animals have been manageable except for the 2 white rhinos at Madison. It took about a year of weekly exposure to get the female rhino to accept biweekly ultrasound examinations.

Henry Vilas Zoo (Madison): I designed this chute after experience with chutes at Oklahoma and Houston. After final construction, it was too long and slightly too wide. After working with the chute, shoulder restraints were added and the guillotine door was modified. These have been effective modifications. This chute has been tested. I am confident in the design as long as the animals are reasonably treated. (Included in video.)

St. Louis Zoo: This chute was patterned after Madison's and constructed so it could be removed. It is all aluminum, making it difficult to modify and expensive, but it is lighter and makes less noise. Shoulder restraints are needed. Animals are not regularly worked; they remain unacclimated to the structure. (No video footage available.)

Sedgwick County Zoo (Kansas): Also patterned after the Henry Vilas Zoo, but made to fit the existing space. The animals are regularly worked. This chute is too long and the flares, at either end to make it flush with the gates, allow the animals to swing their rumps from side-to-side. The gate pipes at the back are too close for operator safety. (Video available.)

Oklahoma City Zoo: This chute unfolds from the wall to fit into a passage. It has some limitations that put rhinos and personnel at risk. (Included in video.)

Henry Doorly Zoo (Omaha): It is the only one with squeeze capability from the side of the animal. The first time this animal was in the chute it was squeezed. It rolled over in the chute, however, this animal was given no time to acclimate. (No video.)

Cincinnati Zoo: This chute has several advantages: the chute is indoors and between caging, solid power doors, good access to the feet and head of the rhino. But one disadvantage that makes rectal palpation almost impossible is a very large post that runs down the middle of the back door, therefore no access to the rectum. (Video available.)

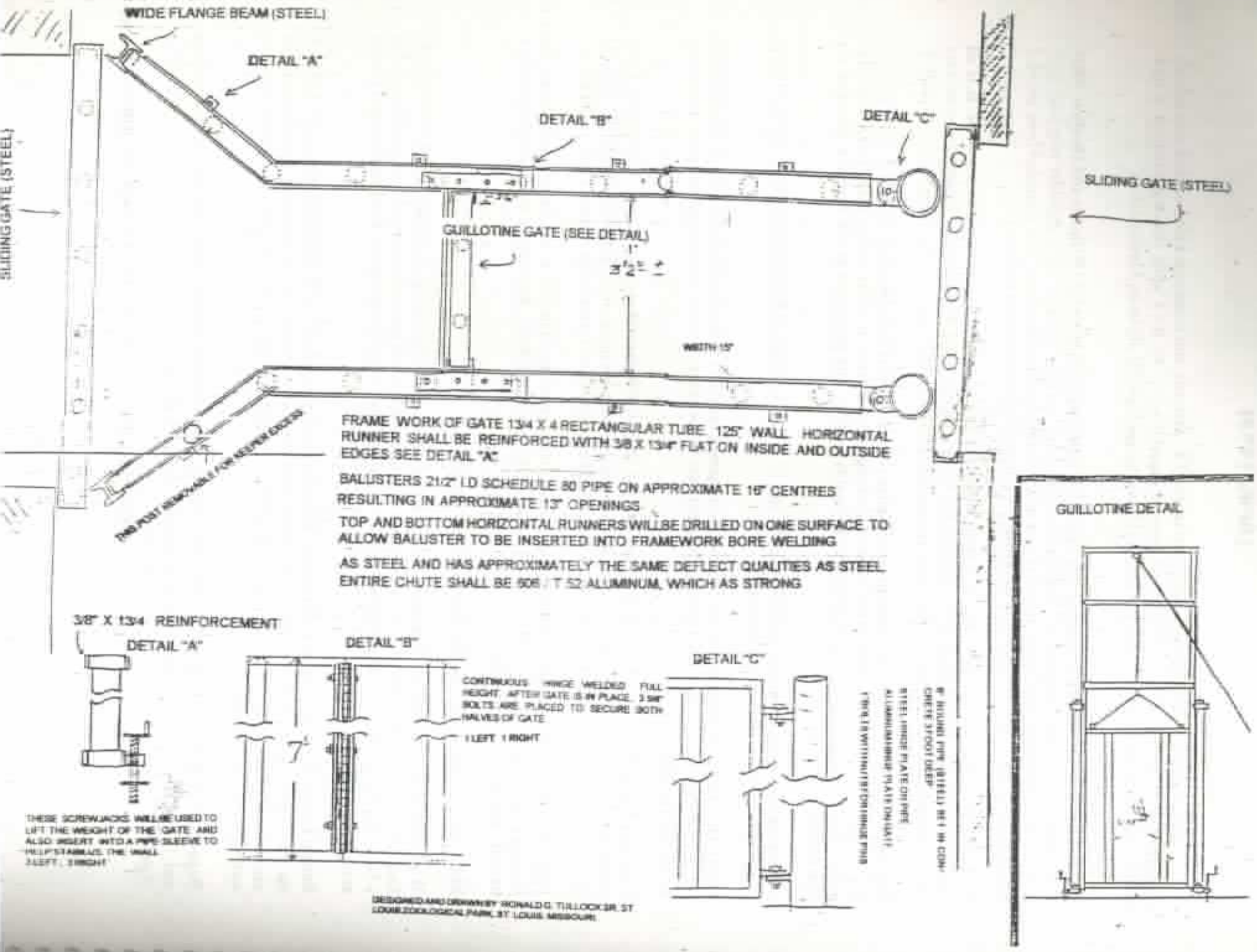
Fossil Rim Preserve (Texas): This chute has some squeeze capability. The "V" in the back door will keep the back legs inside the chute, but this may be a problem if the animal lies down. Animals are not worked regularly. I have not seen it in use. (No video.)

Milwaukee County Zoo: They have an unfinished design.

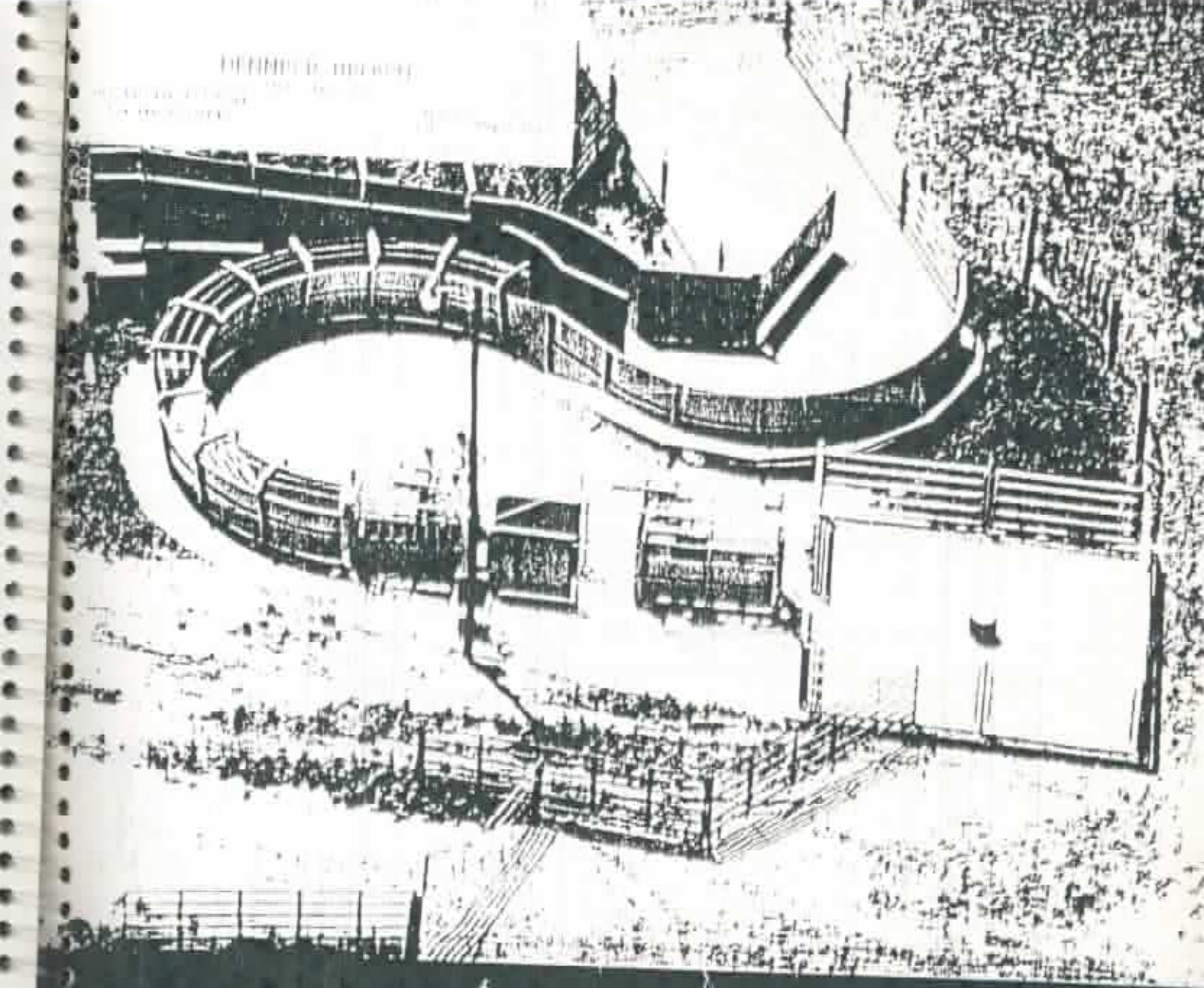
Wild Animal Habitat (King's Dominion): This is a dead-end chute with two gates on one end. It is excessively long, but can be effectively shortened if the animal will allow the first end gate to be closed. However, this gate has a high crossbar which could be dangerous during palpation. The animal climbs on the front feed trough. (Video available)

Sungai Dusun Reserve (Selangor, Malaysia): This chute is on a cement slab with imbedded steel posts. The back three bars are removed to allow entry of the animal. These Sumatran rhinos are so manageable that the chute can usually be used as a dead-end. It is not covered, and has recently been shortened and some side-posts removed to widen gaps. (Video available)

Ragunan Zoo (Jakarta, Indonesia): This chute can squeeze Sumatran rhinos. Cement covers one side and one end. One side can be moved into place as a squeeze. There is a gate at one end and the cover over the structure is slightly higher than the height of a Sumatran rhino.



DESIGNED AND DRAWN BY RONALD G. TILLOCK SR. ST LOUIS ZOOLOGICAL PARK, ST LOUIS, MISSOURI



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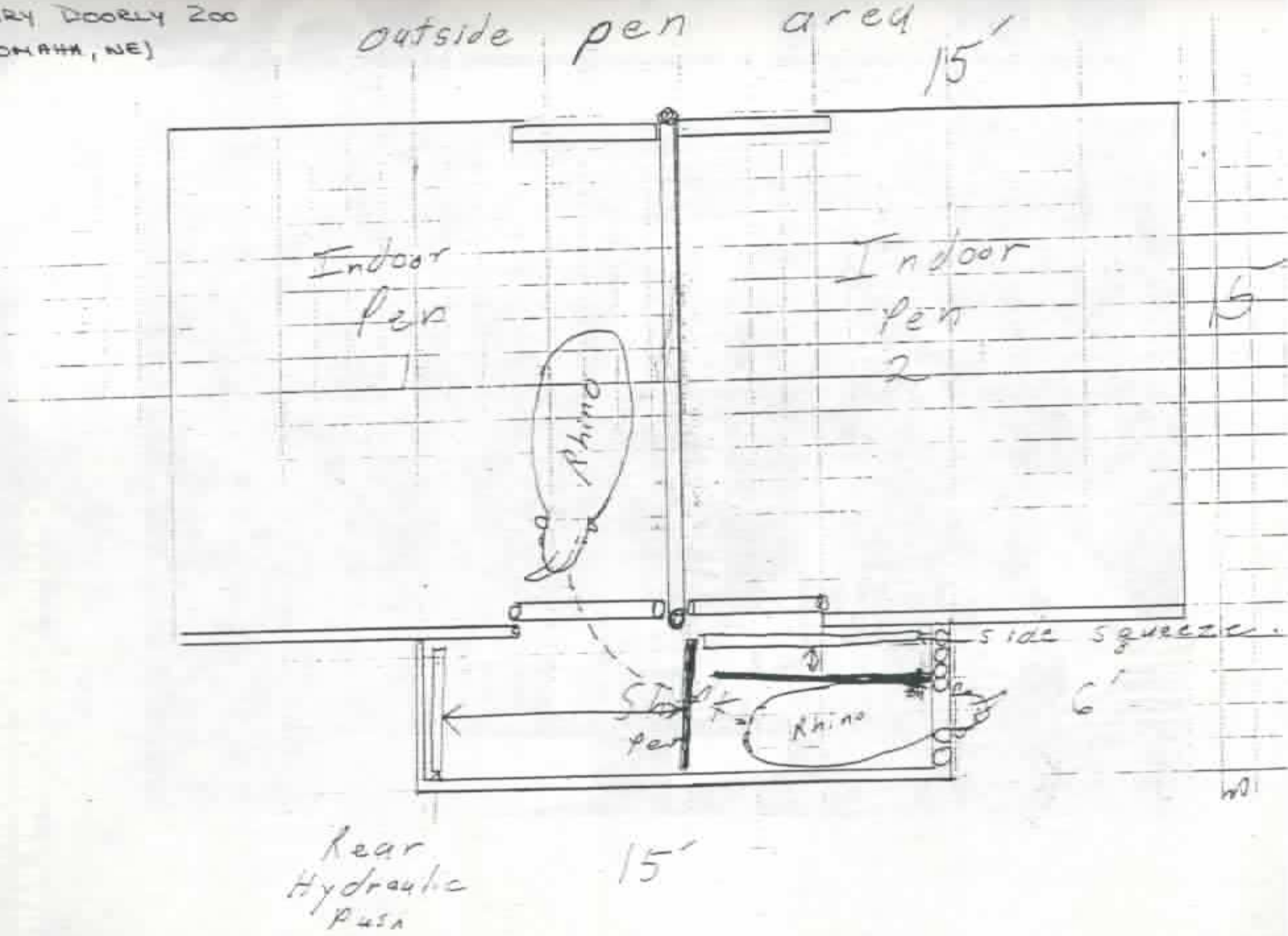
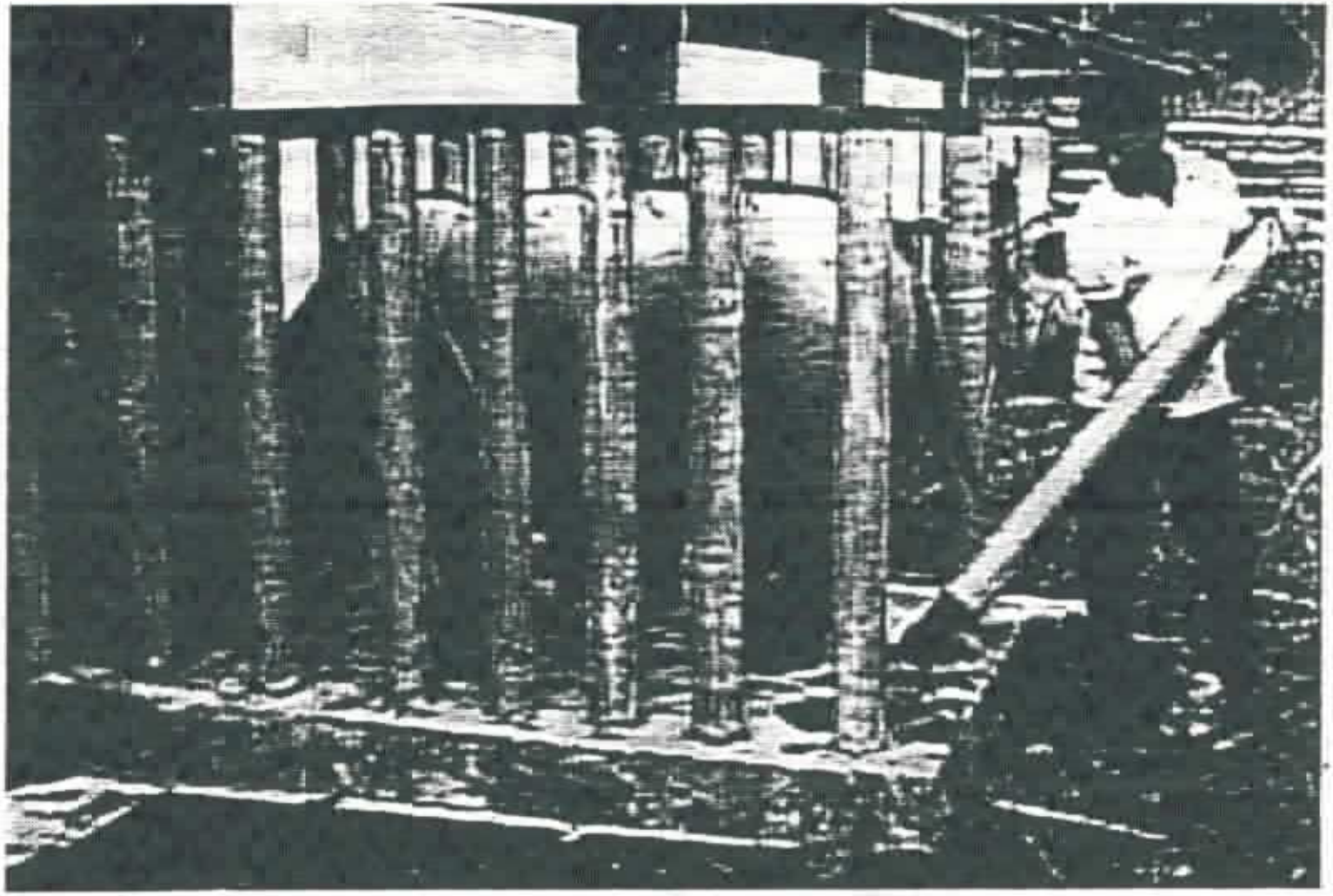
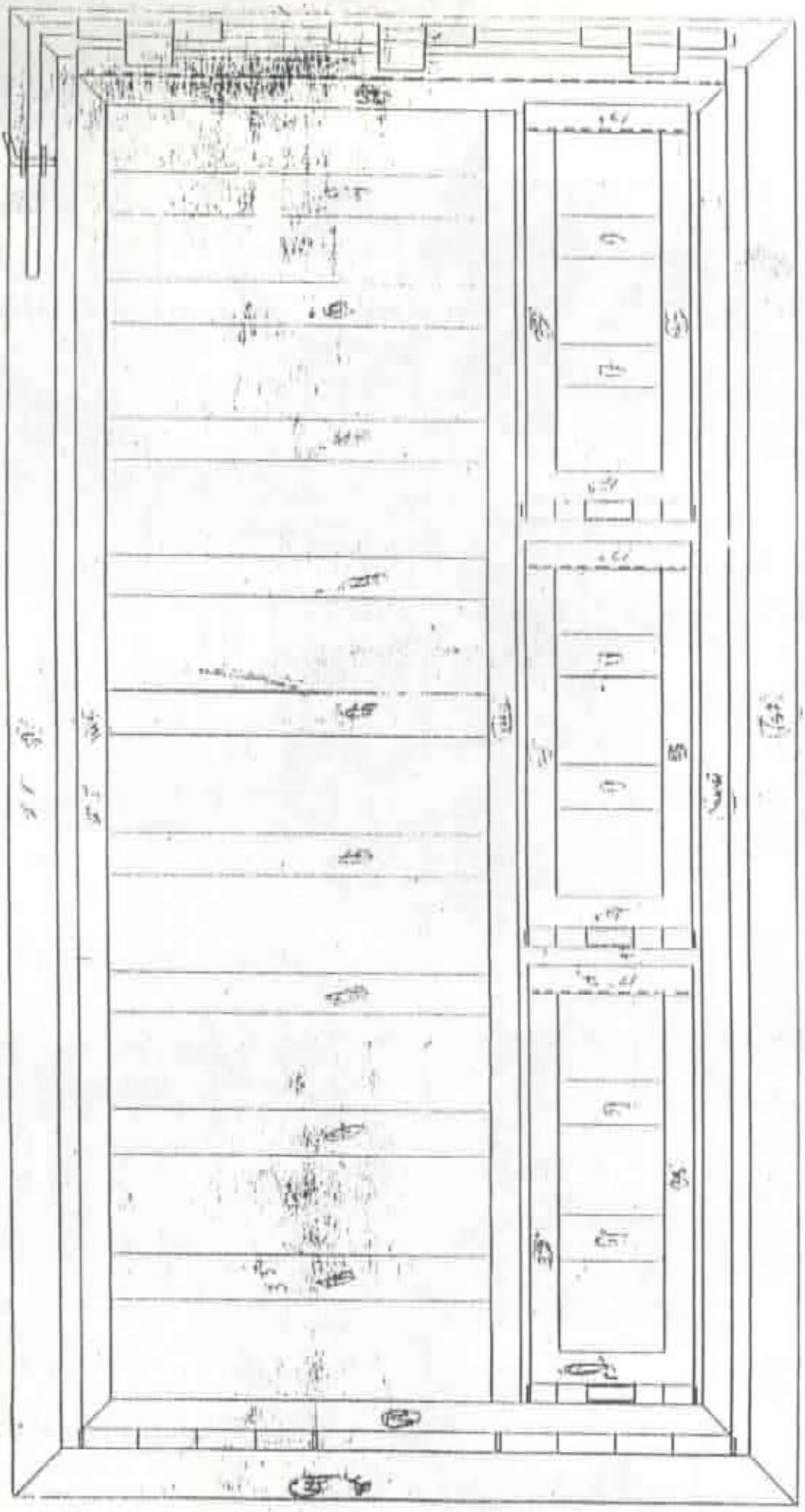
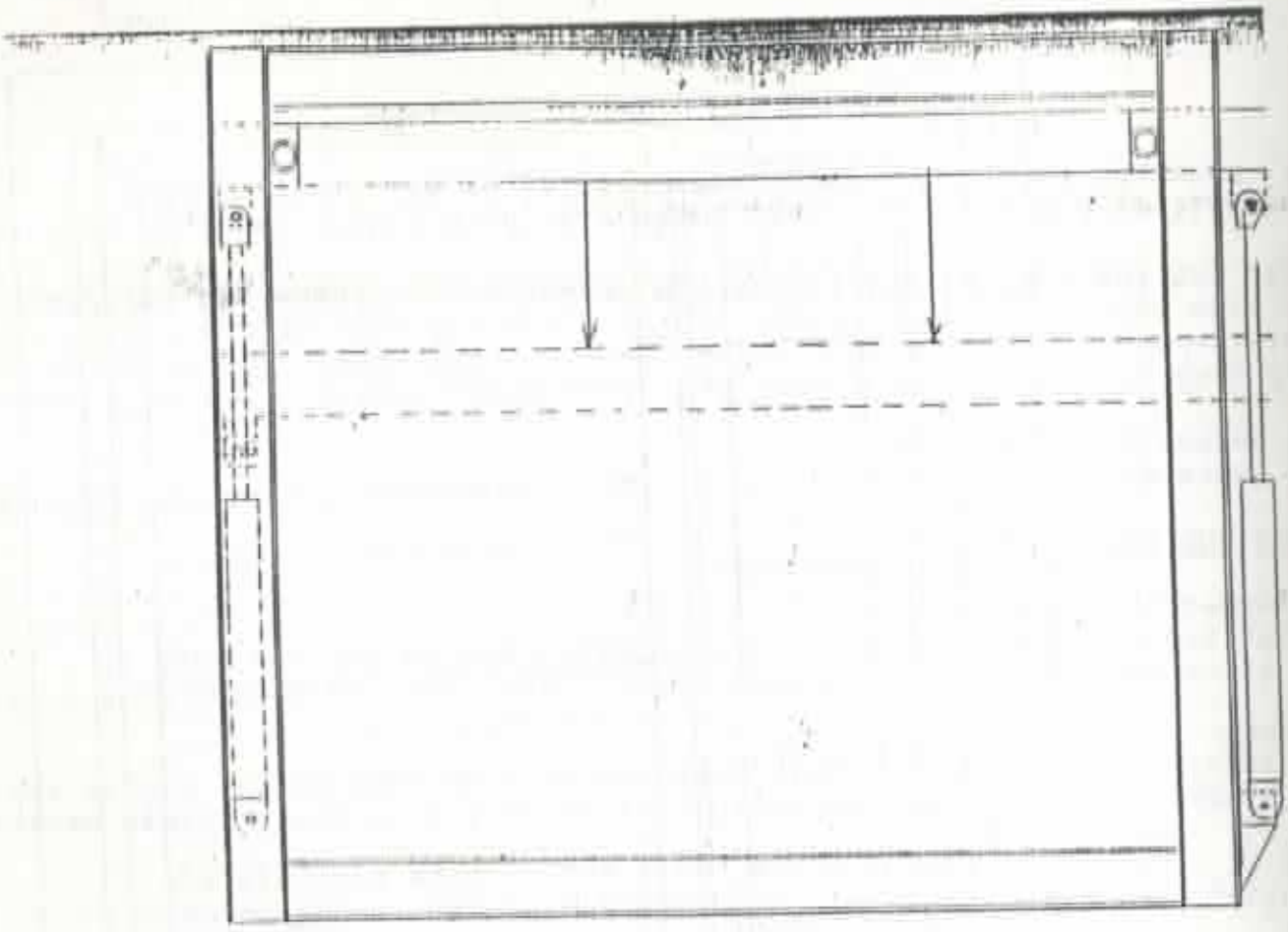


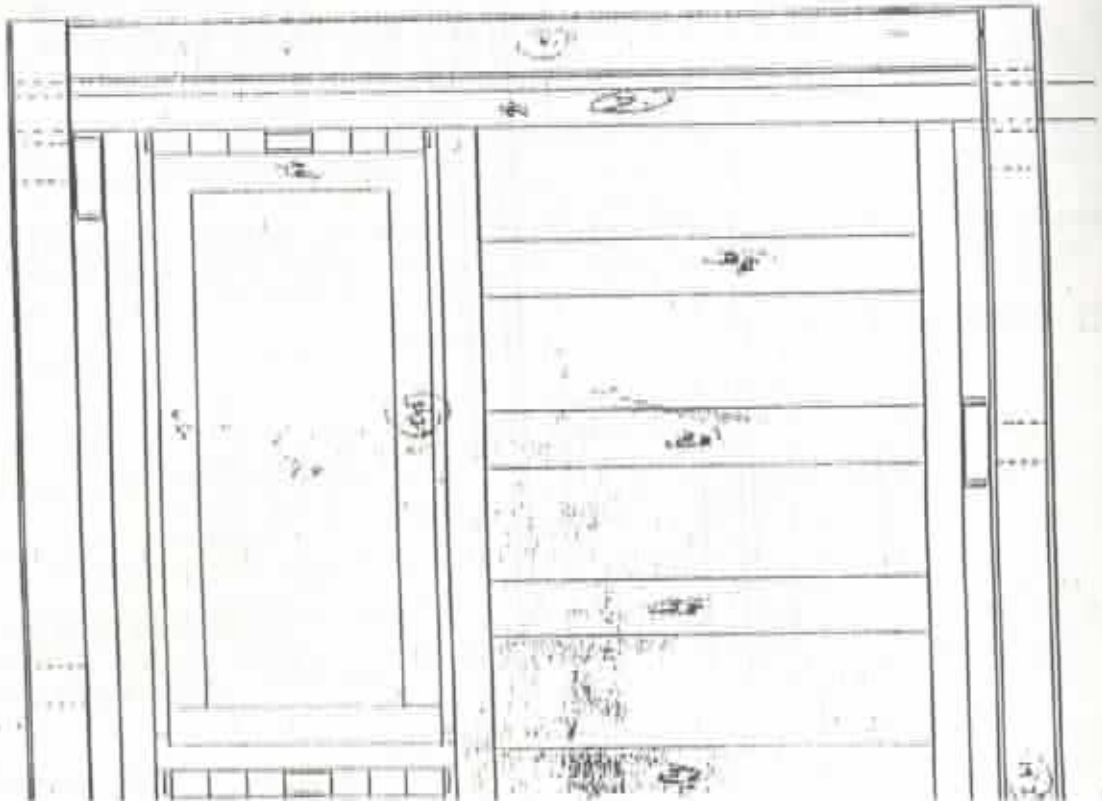


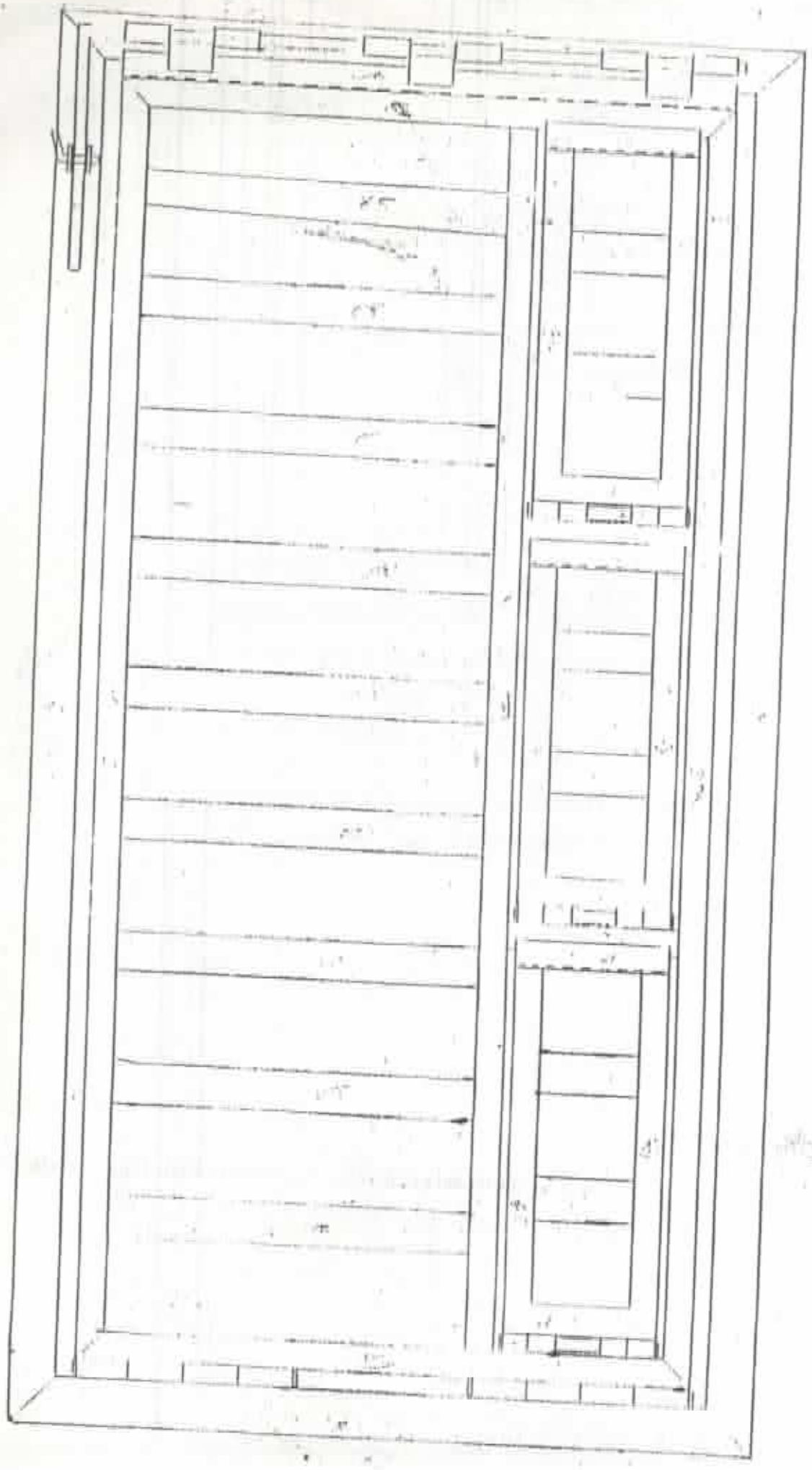
Placing Poles in Chute for Sumatran Rhinoceroses at Sungai Dusun Reserve, Selangor, Malaysia.



Rhino







Chine.

FRAME:

The frame will be constructed of 5" x 5" HEAVY H BEAM (16# per ft.) and will be a solid weld construction and have the ability to be the deck as well as the over all frame with the addition of the electronic scales.

Overall Height of Unit	11' - 8"
Overall Length of Unit	15' - 0"
Overall Width of Unit	11' - 0"
Inside Height	10' - 10"
Inside Length	14' - 2"
Inside Cage Width	8' - 0"

SOLID SIDE PANEL:

The solid side of the unit will be welded into the frame work and will be constructed of 3" x 5" rectangular tubing 4" Schedule 80 pipe.

The hinges will be 1045 C.R.R. - 1 1/4" diameter Cold Drawn Butt Weld Tubing for hinge material for each door opening as shown per print.

The latches will be made of 1045 1 1/4" C.R.R> and will also use the 1/4" wall \ 1 1/4 I.D. bushing material for all latch and hinge pivot points.

MOVABLE SIDE PANEL:

The center frame of the movable side panel will be 5" H-Beam and will move in and out hydraulically with a 36" stroke.

The front and rear halves of the movable side panel will be constructed of 3" x 5" rectangular tubing x 1/4" wall and 4" pipe schedule #80.

All of the door openings (as shown) will have 1 1/4" C.R.R. hinge material and the 1 1/4" I.D. x 1/4" wall bushings will be used on all hinges and latches.

The front and rear halves of the movable side panel will also have a 36" stroke and will move separate of each other giving you the most in adjustment and flexibility.

FRONT AND REAR DOORS:

The doors will be constructed of 3" x 5" rectangular tubing and 1/2" wall and schedule #80 4" pipe.

Each side of the door will open and close hydraulically, and will have a positive throw latch assembly made of 1" x 2 1/2" Flat. These throw latches are also hydraulic. The hinges and bushings are made of the 1 1/4" R.R. shaft and the 1/4" wall x 1 1/4" I.D. bushing for hinges and latches.

Each half of the front and rear doors will have 2 door openings each and will have the same hinge and latch material as all other doors.

HYDRAULICS:

The front and rear doors will work from a single spool valve.

The positive throw latches would work from its own hydraulic valve lever.

The center of the side panel would move in and out 36" with 2 cylinders and a flow divider valve. The divider valve dispenses hydraulic fluids on a 50%\50% ratio keeping the top and bottom even at all times.

The front and back portions would work individually, but the same way as your middle set of cylinders giving you 36" of movement with each half of the movable side panel.

The following price would be the unit described above.

The area where the valves are located would be open area (not enclosed with expanded metal).

The unit would be painted with our enamel tan finish.

All hydraulics would have been tested and pressure settings adjusted prior to shipping.

The unit will be ready to connect to your inlet and outlet lines to our valves upon the solid setting of the unit.

This unit has been designed with the electronic scales as part of the unit therefore becoming part of the bid.

Concrete work will be performed prior to equipment arrival, and prints will be furnished by Cummings & Sons for this layout of how big the pad should be and the placement of the steel pads for us to weld the unit down solid on scale cells.

All unloading expenses and setting up of the unit will be an additional cost.

Total unit price with electronic scales		$38,785.00
	Freight	1,400.00
	Total	$40,185.00

Primo.

Lehmann.