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Source: Journal of Wildlife Diseases, 18(1) : 17-28

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-18.1.17

COLOSTRUM DEFICIENCY IN MULE DEER FAWNS: IDENTIFICATION, TREATMENT AND INFLUENCE ON NEONATAL MORTALITY [1]

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Abstract: Glutaraldehyde coagulation test, zinc sulfate turbidity test, and total protein refractometry were adapted for use in detecting failure of passive transfer of colostral immunoglobulins to mule deer fawns *(Odocoileus hemionus)*. The results of all three tests were similar. Serum total protein concentration was directly correlated to gamma globulin concentration and gave the best indication of morbidity and mortality. Thirteen of 13 fawns with serum total protein concentrations of 5 g/dl or less at 1 to 7 days of age developed diarrhea and died before 17 days of age. Only 1 of 14 fawns having a serum protein concentration above this level became sick and died. Seven of 13 fawns that had serum total protein concentrations of 5 g/dl or less, and that had already developed diarrhea, were given 20 ml of plasma per kg body weight. Although this increased their serum gamma globulin concentrations 0.3 g/dl, none survived. Administration of bovine colostrum to one fawn increased its serum gamma globulin concentration suggesting that mule deer fawns are able to absorb gamma globulins from bovine colostrum.

INTRODUCTION

High mortality, due primarily to diarrhea, often occurs when many mule deer fawns *(Odocoileus hemionus)* are hand-reared together.[13,24] A variety of pathogenic organisms, including *E. coli*, coronavirus and rotavirus, have been isolated from affected fawns. A mild enteritis, marked thymic atrophy and a generalized decrease in adipose tissue are routinely found on necropsy.[21] The high prevalence of infectious diseases and failure to respond to therapy suggest a decreased immunity in these fawns.

Ruminants, such as mule deer fawns, are born with few circulating antibodies.[16,23] There is little placental transfer of antibody[16,25] and little exposure to antigenic challenge *in utero* to stimulate the active production of significant amount of antibodies prior to birth. Several weeks are required for active production of antibodies against the antigens to which the animal is exposed following birth.[14,23] In addition, at birth cellular immunity may be suppressed due to production of glucocorticoids associated with parturition.[14] The most important immediate immunologic protection available to the neonatal ruminant is the immunoglobulins that are absorbed from colostrum,[14,16,23] without which the plasma immunoglobulin concentration is low and the prevalence and severity of diarrhea, septicemia, or pneumonia is greatly increased.[8,10,11,18]

The glutaraldehyde coagulation test, zinc sulfate turbidity test, and total protein refractometry have been used to assess serum immunoglobulin concentrations in calves in field situations.[10,12,15,22] To assist in preventing infectious diseases in animals that have

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low plasma immunoglobulin concentrations, colostrum should be given during the first 24 h of life and plasma should be given intravenously to older animals.[2,17,23] The purpose of this study was to adapt these techniques for use in raising mule deer fawns and to determine if a failure in passive transfer of colostral immunoglobins may be an important factor responsible for the high mortality observed when many fawns are hand-reared together.

MATERIALS AND METHODS

Twelve fawns from 7 tame does and eight from 5 wild does were used in the study. Wild does were captured and transported to the pens approximately 3 months prepartum. Eight additional fawns born to wild does in the wild and received as orphans were also used.

The facility and fawn rearing methods used were the same as those described previously,[13,24] except that concealment barriers from feeders and other humans were not provided for the wild does. In addition, no drugs or parenterally administered fluids were used in the treatment of diarrhea. When fawns developed diarrhea, their formula[13] was initially decreased and later changed to include up to 100% of an oral nutrient, electrolyte containing fluid (Life-Guard®).[2]

Prenursing blood samples were taken when possible. At 24 h postpartum, fawns were removed from their dams. Jugular blood samples, body weights, and hind leg lengths were taken at 1 day of age and weekly for 6 weeks. Ages of orphan fawns were estimated[13] and the same data were collected. Hind leg lengths were measured from the point of the hock to the distal tip of the hoof with the lower leg straightened. Morbidity and mortality were recorded until weaning at 6 to 8 weeks of age.

Blood samples (5 ml) were allowed to clot and then centrifuged. Approximately 2 ml of serum was separated for immediate evaluation with zinc sulfate, glutaraldehyde, and total protein refractometry.[3] Approximately 0.5 ml was frozen for serum protein electrophoresis. Serum protein electrophoresis was done on cellulose acetate strips which were scanned with an automatic integrating densitometer[4] to determine gamma globulin concentration.

The glutaraldehyde coagulation test was conducted by transferring a 0.5 ml aliquot of serum to a 13 mm by 100 mm disposable glass tube. Fifty microliters of a 10% glutaraldehyde solution were added, the tube sealed, the contents mixed by inverting several times, and 15 min later coagulation was evaluated.[22] The formation of a firm button or clot was considered as a positive reaction whereas negative reactions were characterized by no detectable change. Incomplete reactions were characterized by production of a semisolid gel.

The zinc sulfate turbidity test was conducted using a solution containing 208 mg of zinc sulfate · $7H_20$/liter of double distilled water. Using an automatic pipette, 6 ml of the zinc sulfate solution was transferred to 16 mm by 125 mm screw-cap glass tubes. All tubes were kept tightly sealed and refrigerated to avoid possible problems with carbon dioxide contamination.[15] Immediately before use the tubes were warmed to room temperature. The turbidity test was conducted by adding 0.1 ml of serum to each tube, mixing, and 15 min later comparing to a standard. The standard contained 6 ml of the zinc sulfate solution and 0.1 ml of fetal bovine serum that contained 1.0

[2] Norden Laboratories, Inc., Lincoln, Nebraska 68500, USA.

[3] American Optical Corp., Buffalo, New York 14200, USA.

[4] As developed by Helena Laboratories Corp., Beaumont, Texas 77700, USA.

g/dl of purified bovine gamma globulin. As determined by visual observation, sera with less turbidity than that of the standard were called negative and those with more turbidity were called positive. Sera with turbidities indistinguishable from the standard were called questionable.

Fawns, at 24 h of age or when first obtained as orphans, which had sera with total protein concentrations of less than 5 g/dl, as determined by refractometry, were randomly assigned to either a treatment or control group. Fawns in the treatment group received warmed plasma via a jugular catheter at a dose of 20 ml/kg body weight. Animals were restrained initially for catheter placement and then allowed to stand unrestrained while the plasma was administered over a 1 to 2 hour period. Control animals were not treated.

The plasma given was obtained from each of 2 wild captive does 5 days postpartum. Approximately 1 liter of blood was collected aseptically from the tranquilized does into sterile citrate phosphate dextrose collection bags.[1] After centrifugation the plasma was pooled aseptically, transferred into 150 ml transfer packs,[1] and frozen at -20 C for later use.

One fawn was removed from its dam prior to suckling while its twin was allowed to remain with the doe. A precolostral blood sample was taken from the fawn removed from the dam. Beginning at 2 h of age this fawn was fed 50 ml of first milking bovine colostrum from a nursing bottle every 2 to 4 h for the first 30 h of life. At 30 h of age a second blood sample was taken and analyzed. The IgG and IgM concentration of this colostrum was 6,000 mg/dl and 700 mg/dl, respectively, as determined by radial immunodiffusion. Data from this fawn were not included in the mortality results because of this special handling.

Statistical significance of all differences were determined using the unpaired student t test.

RESULTS

Source of fawns, fawn survival, total serum protein, and gamma globulin concentrations, are given in Table 1. The total serum protein and gamma globulin concentrations at 1 day of age and older were lower in fawns that died ($P<0.05$) (Table 1). Nine samples taken prior to nursing all had protein concentrations of 4.3 g/dl or less and gamma globulin concentrations of 0.5 g/dl or less. In 5 of 20 fawns serum concentrations were still near or below these levels at 24 h of age, indicating that these fawns did not receive or absorb colostral antibodies even though they were left with their dams during this period. In three of these fawns in which an additional blood sample was taken at 2-7 days of age serum concentrations were only slightly above that present at 1-2 h of age. As shown in Figure 1, there was a direct linear correlation between serum protein and gamma globulin concentrations in the sera of all fawns used in the study ($r = 0.91$ and $P<0.01$). Serum taken at 24 h of age from the fawn (#226) given bovine colostrum was excluded from the analysis. The serum immunoglobulin concentrations decreased by more than 50% during the period from 1 day to 2 to 7 days of age (Table 1). This indicates the normal catabolism of immunoglobulins passively obtained by the fawns.

The results of the glutaraldehyde coagulation and the zinc sulfate turbidity tests were identical except for one sample which was questionable by the glutaraldehyde coagulation test and positive by the zinc sulfate turbidity test. Both tests were negative at serum total protein concentrations of 4.3 g/dl or less and total gamma globulin concen-

[1] Fenwal Laboratories, Deerfield, Illinois 60015, USA.

trations of 0.5 g/dl or less. The sample in which the results differed between these two tests contained 4.2 g/dl total protein and 0.6 g/dl total gamma globulins.

Overall mortality in the fawns sampled at 24 h of age or older was 52% (14 of 27) (Table 1). All deaths were due to diarrhea and/or septicemia and occurred during the first 17 days of life. All fawns which became clinically ill died. All of the fawns that died had a serum total protein concentration of 5 g/dl or less at 1

TABLE 1. Fawn survival, source of fawns, total serum protein and gamma globulin concentrations in g/dl.

			AGE OF FAWNS					
			1-2 Hrs and Prenursing		24 Hrs		2-7 Days	
No.	S.T.O.*	Dam	Protein	Globulin	Protein	Globulin	Protein	Globulin
Fawns Which Survived:								
200	O	Wild	—	—	—	—	5.8	2.1
203	O	Wild	—	—	—	—	5.2	1.6
204	O	Wild	—	—	—	—	5.7	1.8
211	O	Wild	—	—	7.0	4.0	—	—
212	O	Wild	—	—	—	—	6.4	1.6
225	O	Wild	—	—	—	—	5.3	1.4
223	T	Wild	—	—	6.5	2.1	—	—
205	T	Tame	4.2	0.2	5.7	2.1	5.2	0.7
206	T	Tame	4.3	0.5	5.9	2.1	5.2	1.2
220	T	Tame	—	—	6.0	2.8	—	—
221	T	Tame	—	—	5.7	2.3	—	—
227	T	Tame	—	—	7.5	4.0	5.7	1.7
224	S	Tame	—	—	6.1	3.0	—	—
13		Mean	4.25	0.35	6.31†	2.80†	5.56†	1.51†
		S.D.	0.07	0.21	0.65	0.81	0.42	0.42
Fawns Which Died:								
216	O	Wild	—	—	—	—	4.2	0.6
217	O	Wild	—	—	—	—	5.0	1.4
207	T	Wild	3.0	0.1	3.2	0.4	4.1	0.3
208	T	Wild	—	—	4.4	0.7	4.4	0.7
218	T	Wild	—	—	4.3	1.2	Dead	Dead
219	T	Wild	—	—	3.8	1.0	4.0	1.1
222	T	Wild	—	—	4.7	0.9	Dead	Dead
209	S	Wild	—	—	6.0	2.2	Dead	Dead
215	S	Wild	—	—	3.5	0.7	Dead	Dead
201	T	Tame	3.9	0.0	4.0	0.1	4.3	0.1
202	T	Tame	3.9	0.0	4.5	0.5	4.3	0.4
213	T	Tame	3.4	0.1	3.4	0.1	Dead	Dead
214	T	Tame	3.4	0.2	4.6	0.8	Dead	Dead
226**	T	Tame	3.6	0.3	5.8	1.8	Dead	Dead
210	S	Tame	3.5	0.1	3.5	0.1	Dead	Dead
15		Mean	3.52	0.11	4.15	0.72	4.32	0.66
		S.D.	0.31	0.10	0.77	0.59	0.32	0.45

*Indicates single (S), twin (T), or orphan (O) fawn.

**Beginning at 2 hours of age this fawn was bottle fed 50 ml of first milking bovine colostrum every 2-4 hours for 30 hours. Its twin, fawn #227, was left with the doe.

†Significantly different from those that died ($P<0.05$).

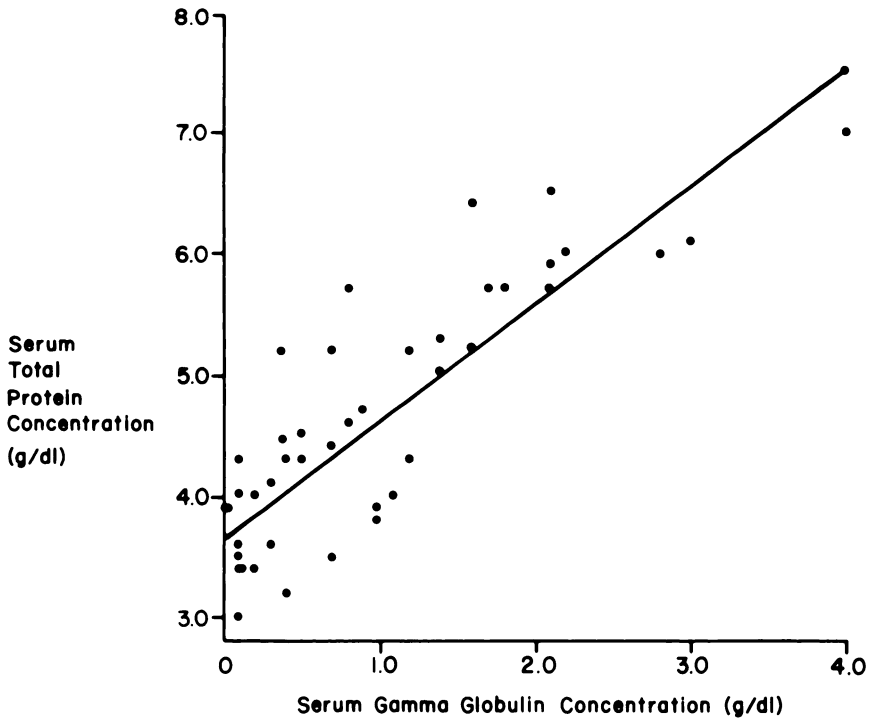

FIGURE 1. Relationship between serum total protein and gamma globulin concentrations in mule deer fawns ($r = 0.91$, $P<0.01$).

to 6 days of age, whereas only 1 of 14 fawns (no. 209) having a serum total protein concentration of 5.2 g/dl or greater became sick and died (Table 1). All fawns that died also had serum gamma globulin concentrations of 1.4 g/dl or less at 1 to 7 days of age, whereas only 1 of 14 fawns having a serum gamma globulin concentration of greater than 1.4 g/dl became sick and died.

Seven of the 13 fawns that had serum total protein concentrations of 5 g/dl or less at 24 h of age were given 20 ml of plasma/kg of body weight by intravenous administration over a 1 to 2 h period. This increased the fawns' serum gamma globulin concentration from 0.58 to 0.92 g/dl. No adverse reactions to plasma administration were noted. In all cases diarrhea was present before and continued after plasma was given. All fawns that became diarrheic died whether plasma was given or not.

Feeding 500 ml of first milking bovine colostrum during the first 30 h of life to a fawn (#226) separated from its dam at birth increased its serum gamma globulin concentration of 0.3 to 1.8 g/dl, however, this fawn developed diarrhea and died. In contrast, this fawn's twin (#227) which was left with the doe had a serum gamma globulin concentration of 4.0 g/dl at this age and survived (Table 1).

Fawns born to wild does in captivity were significantly smaller ($P<0.05$) in both body weight and hind leg length than fawns born to tame does. Fawns having a serum total protein concentration of 5 g/dl or less were smaller than

those with higher serum concentrations but the difference was not significant (Table 2).

DISCUSSION

Hypogammaglobulinemia in calves and lambs due to failure to absorb sufficient colostral antibodies has been reported to be 10-30% in normal herds.[11,18,22] In one study 26% of the calves left with good mothering cows had serum gamma globulin levels below that necessary for survival of housed calves.[7] In the present study 10 of 27 mule deer fawns past 24 h of age had serum gamma globulin concentrations of less than 1.0 g/dl and 3 had concentrations of 1.0 to 1.4 g/dl (Table 1). All of these fawns died from diarrhea and/or septicemia, whereas only one fawn with a serum gamma globulin concentration of greater than 1.4 g/dl became sick and died (Table 1). These results suggest that inadequate absorption of colostral antibodies is one of the major factors responsible for the high mortality which often occurs when many mule deer fawns are hand-reared together.[13,24]

Inadequate absorption of colostral antibodies may occur because: (1) there is an insufficient quantity of colostrum available for the fawn; (2) failure of the fawn to nurse sufficient quantities of colostrum; or (3) failure of the fawn to absorb sufficient quantities of antibodies from the colostrum ingested.

Inadequate colostrum available for the fawn may be due to the loss of colostrum by the doe prior to parturition or to insufficient colostrum production by the doe. Inadequate colostrum production by the doe may be an individual problem in a particular doe or it may be due to inadequate feed intake. Inadequate feed intake has been shown to greatly decrease the amount of colostrum produced by the cow[6] and as a result increases the incidence and severity of diarrhea in calves born to these cows.[3] Adequate quantities of good quality feed were available for the does used in this study and all were in good flesh. Five of the 7 tame does used in this study, however, were first-fawn does and the other two were fawning for the second time. Five of 9 fawns born to the first-fawn does had serum gamma globulin concentrations of less than 1.0 g/dl and died, whereas the 2 fawns born to the 2 older does had serum concentrations greater than 2.5 g/dl and survived. First-fawn does may produce less colostrum and may give less maternal care to the fawns resulting in decreased colostrum intake or delayed nursing. These are thought to be factors responsible for the higher prevalence of hypogammaglobulinemia, diarrhea, and death that is frequently observed in bovine calves

TABLE 2. Size of mule deer fawns born in captivity to wild or tame does and having serum total protein concentrations above or below that necessary for survival (5 g/dl).

Fawns	n	Body Weight at 24 Hrs of Age (kg)*	Hind Leg Length at 1 Week of Age (cm)*
From Wild Does	9	2.68 ± 0.61**	24.20 ± 1.23**
From Tame Does	11	3.70 ± 0.52	26.67 ± 1.17
With High Serum Protein	7	3.62 ± 0.44†	26.48 ± 1.36†
With Low Serum Protein	11	3.25 ± 0.79	25.15 ± 1.82

*Mean ± S.D.
**Significantly smaller than those from tame does ($P<0.05$).
†Not significantly different from fawns with a low serum protein ($P>0.05$).

born to first-calf heifers and younger cows than those born to older cows.

Failure of fawns to nurse sufficient quantities of colostrum may occur for numerous reasons, such as: (1) a larger, more vigorous twin not allowing the other twin to nurse; (2) the fawn is too small or weak to nurse sufficient quantities; (3) poor maternal care; or (4) the fawn is separated from the mother. In this study all fawns born in captivity were left with their dam for the first 24 h of life and no apparent difference in serum gamma globulin concentrations or incidence or severity of disease between single birth and twin fawns was observed. Three of 4 single birth and 9 of 15 twins died. The fawns born to the wild does in captivity were smaller and noticeably more frail than those born to tame does (Table 2) and death losses were higher (7 of 8) than in fawns born to wild does in the wild (2 of 8) (orphans), or in fawns born to tame does (5 of 11).

In a previous study serum gamma globulins and total serum proteins were higher in fawns born to wild does in captivity than those born to tame does.[24] In that study the wild does were observed to give better maternal care than the tame does; therefore, it was thought that the high serum gamma globulin levels in the fawns from the wild does occurred as a result of the ingestion of more colostrum sooner following birth. In that study barriers were provided for the wild does to hide behind, whereas none were provided in the present study. The absence of barriers in this study may have resulted in more stress during pregnancy resulting in the birth of smaller fawns (Table 2). In addition, wild does not provided with concealment barriers may be more reluctant to nurse their fawns. For these reasons concealment barriers are recommended for wild does fawning in captivity.

Failure to absorb antibodies from the ingested colostrum occurs most commonly because of delayed nursing.[23] The ability to absorb colostral antibodies begins to decrease immediately following birth.[20] By 10 to 14 h of age the ruminant's ability to absorb antibodies is decreased by 50% and by 24 h of age significant levels of antibodies can no longer be absorbed.[19] Delayed nursing may occur because of the reasons previously described. Stress and the resulting increase in corticoid secretion may also play a role in decreasing the fawn's immunity to infectious diseases in two ways: (1) by hastening the decline in the neonate's ability to absorb colostral antibodies;[4] and (2) direct inhibition of the immune system.[14,23] In a previous study, however, stress induced immunosuppression of neonatal fawns born in captivity to either wild or tame does was not demonstrated.[24]

Early identification of fawns that have failed to absorb sufficient colostral antibodies may make it possible to take corrective measures to prevent disease in these fawns, or if disease is already present to indicate when treatment may or may not be of benefit. Observation of a fawn nursing its dam is of little benefit as an indication that the fawn has absorbed sufficient colostral immunoglobulin for survival if exposed to pathogenic organisms. The most accurate means presently available of determining the serum immunoglobulin concentration in mule deer and therefore their resistance to infectious disease, is electrophoresis.[25] However, because of the time and laboratory equipment required for electrophoresis it is of little practical benefit as a rapid field test. Single radial immunodiffusion, although more accurate than electrophoresis, cannot be conducted in mule deer because purified mule deer immunoglobulins are not available. In addition, it, like electrophoresis, is of little benefit as a rapid field test.

The zinc sulfate turbidity test is considered to be an acceptable rapid field test for the determination of bovine calf serum immunoglobulin concentrations

provided time, temperature, carbon dioxide concentration in the zinc sulfate solution, and hemolysis are controlled.[15] The zinc sulfate turbidity test depends upon the formation of precipitating salts formed by the combination of immune globulins with zinc ions.[10] The turbidity produced by this precipitate is measured in a spectrophotometer and either absorbance or percent transmission is compared to that obtained from samples containing known quantities of immunoglobulins. To develop this as a field test for mule deer fawns the test was conducted as described and a turbidity standard of 1.0 g of purified bovine gamma globulin per deciliter of fetal bovine serum was used. Bovine gamma globulin and serum were used because purified mule deer gamma globulin and fetal mule deer sera were not available.

All fawns' serum samples that contained 0.5 g/dl of gamma globulin visually appeared to be less turbid than the standard, whereas those containing 0.6 g/dl or more appeared to be equal to or more turbid than the 1.0 g/dl bovine gamma globulin standard. This difference did not appear to be related to the amount of time allowed between adding the fawn's serum to the zinc sulfate solution and comparing it to the standard. The difference may instead be due to more turbidity in mule deer serum than bovine serum when put into a zinc sulfate solution. Since serum from 8 of 15 fawns in which turbidity appeared to be equal or greater than the standard died, a standard containing more than 1.0 g/dl of bovine gamma globulin should be used. All fawns having a serum gamma globulin concentration of less than 1.4 g/dl died whereas all but one having values above 1.4 g/dl survived. Thus a zinc sulfate turbidity test standard equal in turbidity to 1.4 g of gamma globulin per deciliter of fawn's serum should be used. A standard that may be approximately equal to this could be developed by using serum from a normal adult deer.

The glutaraldehyde coagulation test may also be used to detect hypogammaglobulinemia.[22] It has the advantage over the zinc sulfate turbidity test in that the control of time and temperature are not as critical, and the procedures for preventing carbon dioxide contamination of the solution used are not necessary. At low concentrations, glutaraldehyde reacts with gamma globulins in serum to form insoluble complexes. If sufficient quantities are formed the serum coagulates or clots. One-half ml of bovine calf serum containing 1.0 g/dl or greater of gamma globulin and 50 microliters of a 10% glutaraldehyde solution coagulates within 15 min.[22] However, in this study it was found that under similar conditions, coagulation occurred when fawn serum contained 0.6 g/dl or greater of gamma globulin. Since all but one fawn having serum gamma globulin concentrations of less than 1.4 g/dl died, and all but one having concentrations above 1.4 g/dl survived, this test should be modified for use in mule deer fawns so that coagulation occurs at a serum immunoglobulin concentration of 1.4 rather than 0.6 g/dl.

Hypogammaglobulinemia may be detected by measuring total plasma or serum protein concentration by refractometry. Hand held refractometers are relatively inexpensive, simple to use, and no reagents are necessary. Either plasma or serum may be used.[12] An additional advantage is that a venapuncture, which is often quite stressful to the fawn, is unnecessary. A blood sample may be obtained from a pin prick of an ear vein and collected into a hematocrit tube. After centrifugation the tube may be broken to remove the red blood cells and the refractive index of the plasma measured. However, measurement of the refractive index of plasma or serum is not specific for immunoglobulins, as are the zinc sulfate turbidity test and the glutaraldehyde coagulation test.

There are numerous causes of a low serum protein concentration. However,

by far the most common cause in the neonate is hypogammaglobulinemia. Rarely will a neonate with a low serum protein concentration not be hypogammaglobulinemic. In contrast, hypogammaglobulinemia in the neonate may be present even though the total protein concentration is normal or even elevated. This most commonly occurs as a result of dehydration. However, if dehydration is not present the total serum protein concentration in neonatal fawns is a good indication of their serum gamma globulin concentration (Figure 1) and therefore is a good indication of the fawn's immunity to infectious disease. All fawns 24 h of age or older that had a serum protein concentration of 5.0 g/dl or less died, whereas only one of the fawns with a serum protein concentration of 5.2 g/dl or greater became sick or died. If total protein concentration is determined by refractometry on plasma instead of serum, the concentration indicative of adequate or inadequate colostral antibody absorption should be increased by 0.5 g/dl.[12]

Of the three tests used as an indication of hypogammaglobulinemia, the determination of total serum or plasma protein concentration appears to be the best for quick, easy field use for the prediction of morbidity and mortality of fawns. The glutaraldehyde coagulation test and the zinc sulfate test may be good tests for predicting morbidity and mortality if they are modified so that coagulation and turbidity occurs at a serum immunoglobulin concentration of 1.4 g/dl. The zinc sulfate turbidity test appears to be the least desirable for field usage because of the necessity of closely controlling time and temperature and preventing carbon dioxide contamination of the solution used.

It may be possible to protect fawns identified as having low serum immunoglobulin concentrations from disease by either giving plasma intravenously or colostrum orally. If the fawn is less than 16-18 h of age, the results obtained with one fawn indicate that giving bovine colostrum will increase the fawn's serum immunoglobulin concentration. This is supported by the findings that domestic lambs can absorb immunoglobulins from bovine colostrum.[5] Although the fawn given bovine colostrum appeared to have an adequate serum gamma globulin level, it developed diarrhea and died. This may have been due to a lack of specific colostral antibody for the pathogen responsible.[11]

To increase the likelihood that the colostrum contains antibodies against the specific pathogens to which the fawns are likely to be exposed, if possible it may be best to obtain colostrum from cows living near the fawn rearing facility. In addition, and ideally, the cows should be vaccinated against diarrheal producing diseases such as enterotoxemia, salmonellosis, rotavirus, coronavirus, and *E. coli* prior to calving.

Only first milking colostrum should be used since the antibody concentration decreases rapidly in subsequent milkings.[23] Although the optimal amount of colostrum that should be given is unknown, the following is suggested. Give immediately 100 ml every hour for four times. Allow the fawn to nurse as much as possible and give any remaining by stomach tube. Continue to feed as much colostrum as the fawn will nurse at each regular feeding until the fawn is at least 36 h old. Although ruminants are unable to absorb significant amounts of colostral antibodies after 16 to 18 h of age, colostrum may still be beneficial past this age. In addition to the antibodies absorbed, colostrum contains antibodies which assist in preventing disease by blocking microbial adherence to the intestinal mucosa.[23]

After 16 to 18 h of age plasma may be given intravenously to increase the fawn's immunity to infectious disease.

Although in this study giving 20 ml of plasma/kg of body weight to hypogammaglobulinemic fawns increased their serum gamma globulin concentration from 0.58 to 0.92 g/dl it had no affect on survival. However, all fawns were diarrheic before plasma was given and all fawns that had serum gamma globulin concentrations of less than 1.4 g/dl died. Giving plasma intravenously therefore, may be beneficial only if it is given before the onset of disease and in quantities sufficient to increase the serum immunoglobulin concentration to greater than 1.4 g/dl or total protein concentration to greater than 5.0 g/dl. However, two diarrheic fawns given 75 ml/kg did not survive suggesting that plasma transfusions in any amount may be of benefit only when given prior to the onset of disease. As has been shown in bovine calves, once diarrhea begins, treatment is of little benefit if the animal is hypogammaglobulinemic.[2]

Infectious disease occurs because pathogenic challenge overwhelms the animal's resistance. Therefore, to prevent infectious disease, in addition to attempting to increase the animal's resistance, decreasing pathogenic challenge is beneficial.[11] To obtain the maximum decrease in pathogenic challenge the fawn should be raised to at least several weeks of age separate from all other ruminants. With minimal pathogenic challenge, hypogammaglobulinemic fawns may be able to escape infectious disease and death until their own immune system is able to correct their hypogammaglobulinemia.

RECOMMENDATIONS FOR RAISING MULE DEER FAWNS IN CAPTIVITY

1. Provide concealment barriers for captive wild does.
2. Leave fawn and doe undisturbed for the first 36 to 48 h after parturition, unless rejection is observed. This will allow for maximum absorption of colostral antibodies (first 18 h of life) and for maximum benefit from unabsorbed antibodies that remain in the intestine and assist in preventing enteric disease.
3. Measure plasma or serum protein concentration by refractometry in all fawns when they are first separated from their dams or when first obtained.
4. Neonatal fawns that are not dehydrated and have a total protein concentration in the serum of 5.0 g/dl or in the plasma of 5.5 g/dl or less should immediately be isolated from other fawns.
   a. Fawns less than 16 to 18 h of age should be given 100 ml of first milking bovine colostrum every hour for 4 times.
   b. Fawns greater than 18 h of age should be given a minimum of 20 ml of plasma/kg of body weight intravenously.
   c. All fawns should be given first milking bovine colostrum for the first 36 to 48 h of life.
5. Fawns that become diarrheic should immediately be separated from all other fawns until fully recovered to decrease the exposure of other fawns to pathogenic organisms.

Acknowledgements

This study was supported by the Colorado Division of Wildlife and contributions from Colorado Federal Aid in Wildlife Restoration Project W-126-R. We gratefully acknowledge the help and cooperation of R. Bruce Gill, Dr. R.W. Phillips, Dr. T.R. Spraker, Dr. E.S. Williams, Paul Neil, Sue Yancik and Carol Smith.

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Received for publication 26 May 1981