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Evaluation of the welfare of cattle housed in outdoor feedlot pens

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ABSTRACT

The use of open outdoor feedlots for housing large numbers of cattle is increasing in many parts of the world. In these systems cattle are kept in large outdoor pens on a soil surface. One major welfare concern associated with this type of housing is keeping cattle clean and preventing muddy conditions. If the annual rainfall exceeds 20 in (51 cm), it is more difficult to keep the surface dry. In dry parts of the world with low rainfall, it is much easier to keep cattle clean and dry. Another issue is heat stress, and there are warmer parts of the world where shade may be required. The third issue is handling and vaccinating large numbers of cattle. In the U.S. this is an area where conditions have improved because management is now more aware about animal welfare. There are three major outcome based measurements that could be used to assess cattle welfare in open feedlots. They are: scoring of hide cleanliness, panting scoring for heat stress and numerical scoring of cattle handling practices.

1. Introduction

In many countries outside of Europe, beef cattle are housed for fattening in large outdoor pens on a soil surface. Outdoor feedlot housing is becoming more popular. It is important for people interested in animal welfare to learn more about these systems. The discussion in this article will be limited to outdoor feedlot systems and it will not cover indoor housing systems where cattle are housed on either a bedded pack or on a concrete floor. On a single site, large outdoor feedlots may contain from 2000 to over 100,000 cattle. Since the 1970s, many outdoor feedlots have been built in low rainfall areas such as the high plains area of the U.S., Mexico, Northern Australia, and South America. The high plains consists of northern Texas, eastern Colorado, western Kansas, and Nebraska. In countries where outdoor feedlots are used, beef calves are raised on pasture with their mothers. The calves spend approximately half their lives on pasture and the other half in large feedlot outdoor pens. The cows and bulls that produce the calves live on pasture. In the U.S., outdoor feedlots are used to fatten (finish) over 75% of the young steers and heifers raised for beef.

During a long career, the author has had the opportunity to visit large cattle feedlots all over the U.S., Australia, South America, Canada, and Mexico. There are three major welfare issues that are related to this specific type of housing. They are (1) problems with muddy pens and keeping cattle clean, (2) heat stress caused by a lack of shade, and (3) issues associated with handling large numbers of cattle. Fortunately, there are easily implemented solutions for most of these problems. This paper will not cover welfare issues associated with nutrition, feed additives or sickness because these problems can occur in many different types of housing.

2. Problems with mud

2.1. Author's observations in feedlots

The author has lived in three major areas in the U.S. where outdoor cattle feedlots are used. They are the Arizona desert region, Colorado, and Illinois. During all seasons of the year, she worked with outdoor feedlots in many U.S. states, Australia, Canada, and Mexico to improve cattle handling.

Outdoor feedlots located in Arizona where the rainfall was only 15 cm (6 in.) annually, stayed dry, and mud was seldom an issue. Problems with mud increase when outdoor feedlots are located in areas with higher rainfall. Observations from extensive travel indicated that controlling mud in outdoor feedlots becomes increasingly difficult if there is more than 51 cm (20 in.) of annual rainfall. In Illinois where the annual rainfall is much greater, outdoor feedlots get very muddy. Many producers in Iowa and Illinois have switched to indoor facilities for fattening cattle.

The author has also visited many outdoor feedlots located in Northern Australia where the rainfall is low. Maintaining a dry surface for cattle to lay on can be easily achieved there. The average annual rainfall in the inland area near Brisbane, Australia, an area where many outdoor feedlots are located, is 60 cm per year.

2.2. Assessment of the extent of mud problems

A survey conducted at major U.S. beef slaughter plants indicated that 74% of the incoming fed cattle were dirty (Garcia et al., 2008). A more recent updated survey showed that the percentage of clean cattle had increased. In 2011, 51% of the cattle were dirty (McKeith, Gray, Hale, Kerth, & Griffin, 2012). Even though there have been improve-

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ments approximately half the cattle were dirty. Twenty-four percent had dirty bellies and 15% had either mud or manure on the side of their bodies. The data was collected in eight large fed beef slaughter plants located in Western Kansas, Panhandle of Texas, Colorado, and California. These are the major areas in the U.S. where beef cattle are fed in outdoor feedlots. Many U.S. outdoor feedlots are located in Western Kansas where the rainfall is 48–51 cm annually. In this area of Kansas, the author has observed that feedlots usually stay dry. In the early spring the feedlots become muddy due to snow melting and the ground thawing. For approximately eight months out of the year, the Kansas feedlots stay dry. In Alberta, Canada, which is further north, the ground freezes which makes it easier to keep pens dry. Similar to Kansas, the spring is the time when controlling mud become more difficult.

2.3. Effect of mud on beef cattle weight gain

Dee Griffin, a feedlot veterinarian in Nebraska states that 11 cm (4 in.) of mud reduces weight gain (Dee Griffin, Great Plains Veterinary Educational Center, Clay Center, Nebraska, personal communication, 2016). Dikeman and Lawrence (1997) report that cold, wet muddy cattle may have higher energy requirements and the effort to walk through mud may affect feedlot performance. Mud will increase the cost of weight gain (Mader, 2011). According to Chris Reinhardt from Kansas State University, deep mud of over 30 cm (12 in.) inches will increase feed conversion by 25% (Thomas, 2013). Sweeten et al. (2014) states that 11 to 20 cm (4 to 8 in.) of mud will increase feed conversion by 13% and decrease feed intake from 8% to 15%.

There is lack of peer reviewed scientific studies on the effects of mud on beef cattle housed in outdoor feedlots. Most of the available information for beef cattle is in extension publications, livestock magazines, or is based on practical experience (Thomas, 2013; Sweeten et al., 2014). There is some scientific literature is on dairy cows. Dairy cows prefer to lay on dry sawdust compared to wet sawdust, and they also prefer to lie on dry surfaces (Fregonesi, Veira, VonKeyserlingk, & Weary, 2007; Tucker et al., 2015).

2.4. Methods to reduce mud in outdoor feedlots

The author has observed that when an outdoor feedlot is being built the single most important design feature is to do earth moving work so that the pens will drain quickly after it rains. Feedlot pens should have a 2–4% slope away from the feedbunks (Mader & Griffin, 2015; Pohl, 2010; Meat and Livestock Australia, 2013). To drain the entire site, the whole feed yard is sloped a half a percent.

Meat and Livestock Australia (Meat & Livestock Australia, 2013), in their National Guidelines for Beef Feedlots in Australia also recommend that in addition to the slope, the outdoor feedlot should have two cattle drive alleys and a wide drainage alley located between them. This prevents the drive alley from becoming muddy, which would make moving cattle in and out of the pens more difficult.

2.4.1. Management methods to reduce mud and keep cattle clean

There are two basic methods to keep cattle clean in a properly designed outdoor feedlot. The first is the correct stocking density and the second is building mounds for cattle to lie on. This is going to vary depending on the amount of rainfall. Because cattle add moisture from their urine and manure. In low rainfall areas, the absolute minimum stocking density is 10 sq. m. (100 sq. ft.) per animal in low rainfall areas. In areas with higher rainfall it may be 30–60 sq. m. (300–600 sq. ft.) Mader and Griffin (2015) reported that in Nebraska increasing space to 500 $ft.^2$ ($>46\ m^2$) will help keep cattle dry. This area of Nebraska has approximately 72 cm (29 in.) of annual rainfall. There may also be time of year effects. In colder regions where cattle are fed in outdoor feedlots, there is a muddy season when the snow melts in the spring. In warmer regions, there is usually a rainy season where mud problems may increase. During these times, stocking density usually has to be reduced (Holland, 2012). Providing more space will reduce mud on cattle in Nebraska (Mader & Colgan, 2007). Beef cattle should be assessed at regular intervals for cleanliness. Scoring systems are available through the protocols of the Welfare Quality (2009), Garcia et al. (2008) and Grandin (2015). A simple scoring system can be used where (1) clean, (2) dirty legs, (3) dirty legs and belly, and 4) dirty legs, belly, and side of the animal. On some assessment tools, a clean animal is given a score of zero. The score range would be zero to three.

To keep cattle clean, there must be regular pen surface maintenance. A smooth surface will drain more easily. This will require a box scraper equipped with a laser to scrape off the top layer of manure. The goal is to maintain a hard packed surface that will repel water.

Building mounds in feedlot pens will provide cattle with a dry place to lay down. In areas with low rainfall of 15 cm (6 in.) annually mounds are usually not required if the pens re sloped. The top part of the mound should provide each animal with 2–2.5 sq. m. (20–25 sq. ft.) of dry laying space (Holland, 2012). Literature on how to build mounds is difficult to find. Feedlot managers receive most of their information at producer meetings. The recommended height of a mound is 1.5 m (5 ft) with a flat area on top for cattle to lie on. The slope on each side of the mounds should be approximately 10 degrees or (5–1) (Sweeten, Lubinue, Durland, & Bruce, no date). The mounds must be located perpendicular to the feed bunks so rainfall can easily drain towards the drainage area. Pens should always be sloped so water drains away from the feed bunks.

Bedding can also be used to keep cattle clean. Feed trials clearly indicate that bedding cattle and keeping them dry is especially important in cold wet climates. Under some conditions, bedding will improve cattle performance (Mader & Colgan, 2007).

In outdoor feedlots conditions are highly variable and it is difficult to give absolute figures on stocking density. A better approach is to evaluate the cattle based on the outcome measure of cleanliness of the hide. This can be easily assessed with the previously discussed scoring system.

2.4.2. Dust control

During dry conditions outdoor, feedlots can become dusty and that may be detrimental to respiratory health (Edwards, 2010). Dust can be controlled by stocking cattle more tightly during the dry season or by the use of sprinklers. Sprinklers are effective. Unfortunately in the high plains areas of the U.S. some producers had to stop using them due to a lack of well water. Another method for controlling dust is to scrape off the top few inches (cm) of dry layer of manure from the pen surface.

3. Heat stress problems

In the U.S. heat waves have had a significant detrimental effect on beef cattle welfare. On average 5000 head of cattle are lost each year due to heat stress (Mader, 2014). When there was a heat wave in 2011, almost 15,000 cattle were lost in five Midwest and Great Plains states due to heat stress (Mader, 2014). Heat stress losses are most likely to occur with a combination of high temperatures, high humidity, and low air movement. An earlier study done during a heat wave in Iowa indicated that feedlots without shade lost only 0.2% of their cattle and feedlots without shade lost 4.8% (Busby & Loy, 1997).

There are three basic factors that may contribute to heat stress problems in an outdoor feedlot. They are the lack of shade, heavy cattle weights, or cattle with black hides. Black cattle get significantly hotter on the surface of their hides than lighter colored cattle (Mader, Davis, & Brown-Brandt, 2005). Compared to twenty years ago, cattle are being fed to heavier weights. Heavier animals have a more difficult time cooling themselves. The diet fed to the cattle can also have an effect on heat stress. It is beyond the scope of this article to discuss welfare issues associated with feeding practices. The emphasis of this article is

to examine issues associated with housing cattle in outdoor feedlots. Cattle housed in outdoor feedlots in many parts of the world are fed a wide variety of diets.

3.1. Assessment of heat stress with panting scoring

The easiest method for determining if cattle are experiencing severe heat stress is scoring panting (Gaughan, Mader, Holt, & Lisle, 2008). Cattle that breath with their mouths open are severely heat stressed. A simple panting scoring system can be used. When cattle are at rest in their pens, the first sign of severe heat stress is open mouth breathing followed by tongue extension. The further the tongue is extended, the greater the internal body temperature (Mader & Griffin, 2015; Gaughan & Mader, 2014). The complete panting scoring assessment tool is in Mader and Griffin (2015), Mader et al. (2005), and Gaughan et al. (2010).

3.2. Do cattle in outdoor feedlots require shade?

A common criticism of outdoor feedlots is that some yards lack shade. In the hottest areas of Arizona, temperatures can reach 110 degrees F (43 °C). Outdoor feedlots in Arizona have always had shade. The question asked by people concerned about animal welfare, is do cattle living in outdoor feedlots in cooler parts of the U.S. need shade? Many outdoor feedlots in western Kansas, Nebraska, and the panhandle of Texas do not have shades. Most feedlots in Australia have shades. TV coverage of heat stress related deaths in northern Australia motivated the Australian industries to install shades. Shades can also help reduce behavior problems such as fighting bulling behavior in heifers (Mitlohner, Galyean, & McGlone, 2002). Bulling is a behavior where one animal mounts and rides another animal.

3.3. Effect of providing shade on welfare and cattle performance

During the hot summer in the Texas Panhandle, providing shade will reduce panting scores and improve both average daily gain and dry matter intake (Mitlohner et al., 2001, 2002; Barajas, Garces, & Zinn, 2013; Gaughan et al., 2010). Providing shade during hot weather provides both production and welfare advantages. Shade is superior to providing sprinklers for improving average daily gain (Marceillac-Embertson, Robinson, Fadel, & Mitloehner, 2009). When given a choice, dairy heifers preferred shade over sprinklers (Schutz, Roger, Cox, Webster, & Tucker, 2011).

3.4. Design of shades for outdoor feedlots

There should be sufficient shade provided so that all the cattle can lie down in the shadow created by the shade. One study showed that a higher percentage of the cattle got under the shade when 3.3 sq. m. of shade was provided versus 2 m^2 (Sullivan, Cawdell-Smith, Maderf, & Gaughan, 2014). The amount of space needed will depend on cattle size. Space is sufficient if all the cattle will lie down in the shadow of the shade. This is an easy to use assessment measure for determining the space requirements for shade.

In arid areas which are the best locations for outdoor feedlots, shades should be oriented north and south (Meat & Livestock Australia, 2013). This orientation enables the shadow to move which keeps the ground surface dry. The author observed a shade in Arizona that was laid out in the wrong east/west orientation. Under this shade there was a strip of soil under that never dried out. After weeks of sunshine and no rain, the ground remained muddy. When shades are laid out correctly north and south, the ground will stay dry. To keep cattle cool shades should be 3 m (10 ft.) to 3.5 (12 ft.) above the ground.

4. Water requirements

Having a plentiful supply of fresh clean water is essential for good animal welfare. Assessment of access to drinking water is an important part of the Welfare Quality (2009) assessment for beef cattle. Water requirements can greatly increase during hot weather. Dee Griffin, a Nebraska feedlot veterinarian, emphasizes the importance of using large diameter plumbing that will provide sufficient water flow to keep troughs full on the hottest day. The Alberta Department of Agriculture and Forestry has recommendations for water system requirements in colder regions (Alberta Dept. of Agriculture and Forestry, 2015). Water intake greatly increases with both high average temperatures and high humidity (THI) (Arias & Mader, 2011). Australian data indicates that water consumption can vary from 45 l per animal per day on a cool day to 90 l on a hot day (Australian Cattle Standard Working Group, 2013). A new study shows that placing water troughs on the fence line where cattle in adjacent pens can share them, greatly increases the risk of spreading diseases such as Bovine Respiratory Disease (BRD). Water troughs for cattle which have recently arrived in feedlots should be located in the middle of the pen (Hay, Morto, Clements, Mahoney, & Barnes, 2016). It is likely that sharing of water troughs will be less of a problem after cattle have been in a feedlot for several months.

From a practical standpoint, how does one determine if cattle have access to adequate water? On hot days over 90 °F (32.2 °C) if cattle are standing around a water trough that has been nearly sucked dry the water flow is not adequate.

5. Protection from cold stress

Extreme cold weather events in the high plains area of the U.S. can cause large death losses (Belasco, Cheng, & Schroeder, 2015). In Canada and the Northern U.S., in states such as North and South Dakota, cattle in open feedlots must be protected from cold stress with either windbreak fences or bedding. Cattle weight gain can be improved by using bedding (Mader & Griffin, 2015). During the cold winter months in Nebraska, cold stress from mud will increase an animal's energy requirements. Serious welfare issues can occur if cattle with thin summer haircoats are moved to cold snowy areas. The length of the haircoat determines the animal's critical temperature. This is the temperature where the animal does not have to expend energy to maintain its internal body temperature. Brandle, Quann, Johnson, and Wright (1994) developed the following guide shown on Table 1.

In the Northern U.S. and the major cattle feeding areas in Alberta, Canada, windbreak fences are used. These fences help prevent cold stress from wind chill. They are constructed from vertical wood planks with a space between them. The correct spacing makes 20% of the fence open (Ontario Agriculture, no date). Solid fences should not be used because large snowdrifts may result. Windbreak fences are usually 2 m (6 ft.) to 2.5 m (8 ft.) tall. The author has visited many Alberta, Canada feedlots where windbreak fences were constructed on three sides of the pen. The side with the feed trough is left open. Shades are not required in these northern locations.

6. Outdoor feedlots have highly variable conditions

Outdoor feedlots with a soil surface can be used in both cold and hot climates. The major variable that limits the use of outdoor feedlots

Table 1
Critical temperature where cattle can maintain their body temperature without expending energy. Adapted from Brandle et al. (1994).

Thin, short summer hair coat	15 °C (59 °F)
Dry, short winter hair coat	0 °C (32 °F)
Dry, long, heavy winter hair coat	−7.8 °C (18 °F)
Wet hair coat destroys ability to insulate from the cold	15 °C (59 °F)

is high rainfall. This is due to problems with controlling mud. The author has visited outdoor feedlots in both the Midwest area of the United States such as Iowa and Illinois and the high rainfall areas of the southeastern U.S. In both of these areas, the pens can get extremely muddy even when good management practices are used. Today cattle feeders in these high rainfall areas have constructed indoor facilities with either a concrete slatted floor or a bedded pack. In the cold northern areas of Canada and the Dakotas, windbreak fences are installed in many feedlots. In the hottest areas of the world, such as Arizona, Southern California, and Northern Australia, most outdoor feedlots are equipped with shades. The areas that mostly do not have shades are located in the High Plains area of the U.S. where temperatures are lower. More studies are needed to show that shades will benefit the animals housed in these areas.

7. Assessing the outdoor feedlot environment for cattle welfare

The trend in animal welfare assessment is to use animal based outcome measures instead of directives on how to build animal housing (Velarde & Dalmau, 2012; Grandin, 2015, 1998). Two important outcome measures to assess the environment in an outdoor feedlot is panting scoring for signs of severe heat stress and cleanliness of the animal's legs and hide. The use of these two assessments will help prevent some of the worst welfare problems with either mud or heat. Both of these measures are easy for people to learn to use. Problems with swollen legs and knee joints is seldom a problem when cattle are housed on dirt.

7.1. Advantages of the outdoor dirt feedlot environment

A big welfare advantage of outdoor feedlots is the absence of swollen hocks, swollen knee joints and other leg injuries. Cattle housed on concrete slots can get swollen joints (Wagner, 2016). Dairy cattle housed in cubicle stalls (free stalls) can get severe hock lesions in poorly designed or poorly managed stalls (Fulwider, Grandin, Garrick, Engle, & Rollin, 2007). Well-managed free stalls with loose soft bedding will prevent leg injuries (Cook, Hess, Foy, Bennett, & Bratzman, 2016). An easy to use assessment tool is (1) normal leg, (2) hair loss on the joint, (3) joint swelling smaller than a tennis ball or baseball, (4) larger swelling. Always score the worst leg (Fulwider, et al., 2007). Lameness should be assessed in all types of housing systems.

8. Cattle handling and treatment of newly arrived cattle

Death losses and morbidity can vary greatly. Much of this variation is due to the condition of the arriving cattle. Both research and practical experience has shown that preweaning cattle calves 45 days before they leave the ranch of origin will reduce bovine respiratory disease. In the U.S., up to 40% of the newly arrived cattle were weaned on the day of transport from the ranch of origin to the feedlots. Tucker et al. (2015) lists this as a major welfare issue. A rancher is not going to prewean and vaccinate his calves if he is not paid to do it. There are two welfare issues, (1) Preparation of the calves before they arrive at an outdoor feedlot and the environmental conditions at the feedlot. The emphasis of this paper is to examine welfare issues specifically associated with outdoor feedlot environments. Welfare issues associated with a lack of preparation before beef calves leave the ranch of origin is a separate issue, which can cause problems in many different types of housing.

8.1. Assessment of cattle handling practices

To handle large numbers of incoming cattle an outdoor feedlot must have ramps for unloading cattle arriving on many trucks. Design for cattle handling facilities can be found in Grandin (2014) and Grandin and Deesing (2008). One area where animal welfare has really improved is handling large numbers of cattle. When the author started her career in the 1970s and 1980s, cattle handling was extremely rough and electric prods were used on most of the animals. Electric prod use or excessive pressure from restraining devices can increase both vocalization (moos and bellows) and cortisol (Simon, Hoar, & Tucker, 2016; Grandin, 2001; Hemsworth et al. 2011; Dunn, 1990). A Brazilian study showed that improved cattle handling practices and the elimination of yelling, dogs, and electric prods lowered cortisol levels (Lima, Negrao, Paz, & Grandin, 2016). The National Cattlemen's Beef Association (2009) has a Feedlot Assessment Guide that contains a scoring system for animal handling. When cattle are being handled, stock people can be assessed on the percentage of cattle moved with an electric prod, cattle falling while exiting from the squeeze chute, stumbling, vocalization in the squeeze chute and miscaught in the squeeze chute. The use of numerical scoring to assess cattle handling has been very effective for improving cattle handling at beef slaughter plants (Grandin, 1998, 2006, 2001).

Two surveys conducted by Woiwode and Grandin (2014), Woiwode et al. (2016) and Barnhardt (2015) both indicate that cattle handling in large U.S. outdoor feedlots has improved. Both researchers used the National Cattlemen's Beef Association (2009) assessment tool. Woiwode and Grandin (2014) surveyed 26 large feedlots in Colorado, Nebraska, and Kansas. Barnhardt (2015) surveyed 56 large feedlots in Kansas. One hundred cattle were scored during normal processing procedcures when the animals arrived at the feedlot. The animals were restrained in a hydraulic squeeze chute, and vaccinated and eartagged. The two surveys were done independently with no collaboration (Table 2).

The management of large commercial feedlots has worked hard to improve handling. The single biggest factor which determines the quality of cattle handling is the attitude of management. Both Grandin (1997) and Noffsinger, Lukasiewicz, and Hyder (2015) have worked with managers to improve feedlot cattle handling. A survey of cattle handling at 30 California cow calf ranches indicates that there was excessive use of electric prods that was associated with cattle balking, falling down, and vocalization (Simon et al., 2016).

In the two feedlot surveys, all of the cattle handling was conducted in hydraulic squeeze chutes. The management had set the pressure settings to control the maximum amount of pressure applied to the cattle. Reducing pressure applied to the animal will reduce vocalization (Grandin, 2001). In the Simons et al. (2016) survey, ranches with hydraulic squeeze chutes had significantly higher vocalization scores

Table 2
Average scores on handling measures during vaccination of cattle in large U.S. feedlots and on cow calf ranches.

	Outdoor Feedlot Woiwode Survey (2014)	Outdoor Feedlot Barnhardt Survey (2015)	Pasture Ranch Simon (2016)
Percentage of cattle falling exiting the squeeze chute	0.8%	0.2%	0.9%
Percentage of cattle stumbling while exiting	6.7%	1.8%	4.7%
Percentage vocalizing in squeeze chute before the procedures were started	1.4%	0.9%	5.2%
Percentage of cattle miscaught by the headgate	2.2%	0.2%	14.5%
Percentage of cattle moved with an electric prod	5.5%	4%	25%

compared to ranches with manual squeeze chutes. This is probably due to more cattle handling training at the large feedlots, and management awareness of the importance of preventing excessive pressure from being applied. The use of the BQA numerical scoring tool is recommended so that managers can determine if handling practices are improving or becoming worse.

Codes of practice for handling beef cattle clearly state that electric prods must never be used on sensitive parts of the animal such as genitals (National Farm Animal Care Council, 2013). Many people who are concerned about animal welfare often assume that large farms have worse practices. The large outdoor feedlots in the U.S. high plains had better cattle handling practices compared to the California pasture ranches. This is likely to be due to a greater emphasis on training feedlot employees.

9. Conclusions

When cattle are housed in outdoor feedlots with a dirt surface, there are three main critical points where animal welfare indicators should be evaluated with numerical scoring. They are: (1) panting scoring for feedlots in hot climates to measure heat stress, (2) cleanliness of the hide and legs to assess muddy conditions, and (3) Numerical scoring of cattle handling practices. Another important welfare issue that should be assessed is access to both clean water and veterinary care. This paper discussed issues that are specific to outdoor feedlots. Well known issues concerning cattle diet and lack of preparation of incoming cattle however have not been discussed, because these problems can occur in many different types of housing.

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