Disc pasture meter

John L. Godlee

28th April 2021

1 Introduction

The Disc Pasture Meter (DPM) is a simple apparatus used to estimate grass biomass. The DPM consists of a plate of a known weight that is lowered onto the grass sward and the height after settling is recorded. An allometry of disc settling height and grass biomass measured through destructive harvesting is generated using a subset of sample locations, to allow estimation of biomass directly from disc settling height. First described by Castle (1976) and further by Bransby and Tainton (1977) it became a popular method due to its simple design and ability to perform rapid measurements. The method remains particularly popular among rangeland and savanna ecologists (Gwate et al., 2021; Harmse, Dreber, and W. S. Trollope, 2019; Charles-Dominique et al., 2018).

Note that there is a similar instrument called the rising-plate meter (RPM) that is also used for estimating grass biomass, developed by Earle and McGowan (1979). Following the publications by Bransby and Tainton (1977) and Earle and McGowan (1979) which first described the DPM and RPM, respectively, the RPM differs subtly from the DPM in its application. Using an RPM the disc is rested on the top of the grass sward manually and the rod is lowered to the ground second, while using a DPM the rod is lowered to the ground first and the disc is lowered second, or dropped from a known height. The fundamental measurement of disc height is identical between the two methods however, and there is some overlap in usage of the terms in the literature. RPMs have been the subject of further development to digitise their readings and incorporate advanced sensor technology (McSweeney et al., 2019; Bareth and Schellberg, 2018), while the term DPM is usually reserved for apparatus requiring manual measurement. There is also some variation in terms among fields of research. Researchers of agricultural pasture and in temperate climes refer more often to RPMs, while researchers of tropical savanna and arid grassland more often refer to DPMs. In this document I limit discussion to the DPM.

Below, I describe the dimensions of DPMs from a number of studies in the peer-reviewed literature, and finally present instructions to build a robust DPM that conforms to conventional dimensions used in other studies, using materials that are readily available throughout the world.

2 Previous studies

To gather studies I used the ISI Web of Science with the following search term:

```
(TOPIC:("disc-pasture meter") OR TOPIC:("disc meter") OR TOPIC:("disc pasture meter")
OR TOPIC:("disk pasture meter") OR TOPIC:("disk meter")) AND LANGUAGE:(English).
```

Only the studies which described or cited descriptions of a DPM design are included in Table 1.

Table 1: Comparison of DPM dimensions from previous studies. ⌀= diameter.

Publication	Rod length (cm)	Rod ext. ⌀(mm)	Sleeve length (cm)	Sleeve int. ⌀(mm)	Disc ⌀(cm)	Disc thick. (cm)	Mass of free parts (kg)	Disc	Drop height (m)	Followed
Aiken and Bransby (1992)	-	-	-	-	45	-	1.36	-	-	-
Bransby and Tainton (1977)	180	22	120	27	45.8	1.5	1.5	-	-	-
Brenner et al. (1994)	150	12.5	25	2.5	60	0.5	1	-	1.5	Palazzo and Lee (1986)
Brockett (1996)	-	-	-	-	45	-	1.5	-	-	Bransby and Tainton (1977)
Bryan, Thayne, and Prigge (1989)	-	-	-	-	50	-	2.2	-	-	- Vartha and Matches (1977)
Castle (1976)	80	3.1	20	3.2	30	0.091	0.2	Aluminium	-	-
Charles-Dominique et al. (2018)	-	-	-	-	45	-	1.5	-	-	Bransby and Tainton (1977)
Cooper et al. (2017)	-	-	-	-	46 (square)	-	-	-	-	E. B. Rayburn and S. B. Rayburn (1998)
Dörgeloh (2002)	180	-	-	-	45.8	-	-	-	-	Bransby and Tainton (1977)
Dougherty et al. (2013)	-	-	-	-	46 (square)	0.56	~1.5	-	-	E. Rayburn and Lozier (2003)
February et al. (2013)	-	-	-	-	-	-	-	-	-	Bransby and Tainton (1977).
Fehmi and J. M. Stevens (2009)	-	-	-	-	45.7 (square)	0.52	1.263	Acrylic	-	E. B. Rayburn and S. B. Rayburn (1998)
Fushai (2006)	-	-	-	-	60	-	-	-	-	Bransby and Tainton (1977).
Ganguli et al. (2000)	-	-	-	-	40 (square)	0.6	1	Acrylic	-	E. B. Rayburn and S. B. Rayburn (1998)
Gwate et al. (2021)	-	-	-	-	-	-	-	-	-	Bransby and Tainton (1977)
Hardy and Mentis (1985)	-	-	-	-	-	-	-	-	-	Bransby and Tainton (1977)

Harmoney et al. (1997)	-	-	-	-	31.6 (square)	-	-	-	-	Santillan, Ocumpaugh, and Mott (1979)
Harmse, Dreber, and W. S. Trollope (2019)	180	-	-	-	45.8	-	-	-	-	Bransby and Tainton (1977) and W. S. W. Trollope and Potgieter (1986)
Little, Hockey, and Jansen (2015)	-	-	-	-	45.7	-	1.5	-	0.6	Bransby and Tainton (1977), Danckwerts and W. Trollope (1980), and W. S. W. Trollope and Potgieter (1986)
Powell (1974)	-	-	-	-	35.6	-	-	-	-	Phillips and Clarke (1971)
Nieto-Quintano et al. (2018)	-	-	-	-	-	-	-	-	-	Bransby and Tainton (1977)
Randle, N. Stevens, and Midgley (2018)	-	-	-	-	-	-	-	-	-	W. S. W. Trollope and Potgieter (1986)
E. B. Rayburn and S. B. Rayburn (1998)	100	-	-	-	46 (square)	5.6	-	Acrylic	-	-
Santillan, Ocumpaugh, and Mott (1979)	180	20	10	-	80	1.5	2.96	-	-	Phillips and Clarke (1971)
Sharrow (1984)	-	-	15	-	50	0.5	1.1	Acrylic	-	-
Teague et al. (1996)	-	-	-	-	45	-	-	-	-	Bransby and Tainton (1977)
Thrash (1998)	-	-	-	-	45.7	-	1.5	-	0.6	Bransby and Tainton (1977)
W. S. W. Trollope and Potgieter (1986)	-	-	-	-	-	-	-	-	-	Bransby and Tainton (1977)
Coller, F. Siebert, and S. J. Siebert (2013)	-	-	-	-	-	-	-	-	-	Zambatis et al. (2006)
Vartha and Matches (1977)	150	-	66	-	50	-	~2.5	-	0.8	Bransby and Tainton (1977)
Veen, Geuverink, and Olff (2011)	-	-	-	-	20	-	0.07	Styrofoam	-	Bransby and Tainton (1977) and Sharrow (1984)
Virkajäarvi (1999)	110	22	-	-	30	0.2	0.215	Aluminium	-	-
Zambatis et al. (2006)	180	22	97	27	45.8	1.5	1.5	-	-	-

The majority of articles reviewed in Table 1 cite Bransby and Tainton (1977) or E. B. Rayburn and S. B. Rayburn (1998) as the basis of their DPM design. 180 cm appears to be a popular rod length, though this could be altered to any height as long as it is tall than the grass material. Two principal methods of using the disc emerged from the literature. The first, which tends to use a lighter disc, involves carefully lowering the disc onto the grass, and holding it at the position where the disc touches the top of the grass sward (Veen, Geuverink, and Olff, 2011), the second, which tends to use a heavier disc involves lowering or dropping the disc from a pre-determined height and letting it settle, sometimes for a pre-determined period of time (Vartha and Matches, 1977). The first method measures sward height only, and cannot be used reliably to estimate biomass, while the second method can be used to estimate biomass. Few studies included the drop height in the article, and many did not include the mass of the free-moving parts, both of which are important information when comparing results among studies.

3 Instructions for a Disc Pasture Meter

Here I provide detailed instructions for building a robust DPM using materials that can be commonly found at hardware stores around the world. The design revolves around the flange piece. It is important that the sleeve and the flange have a tight fit. Therefore the flange, sleeve and bolts should ideally be sourced ahead of time. The rod and disc, being the bulkiest materials, could be sourced closer to the field site if necessary. The flange is of the kind that is normally used to attach a water pipe against a flat surface like a water tank. They are readily available where plumbing supplies are sold. PVC water pipe is also a suitable material for the rod and sleeve. Remember that the sleeve must be free moving against the rod, there should be no friction. Ideally the internal diameter of the sleeve should be about 2 mm larger than the external diameter of the rod. The materials below are based on UK conventional measurement systems. If sourcing the materials in another country the exact dimensions may have to be altered.

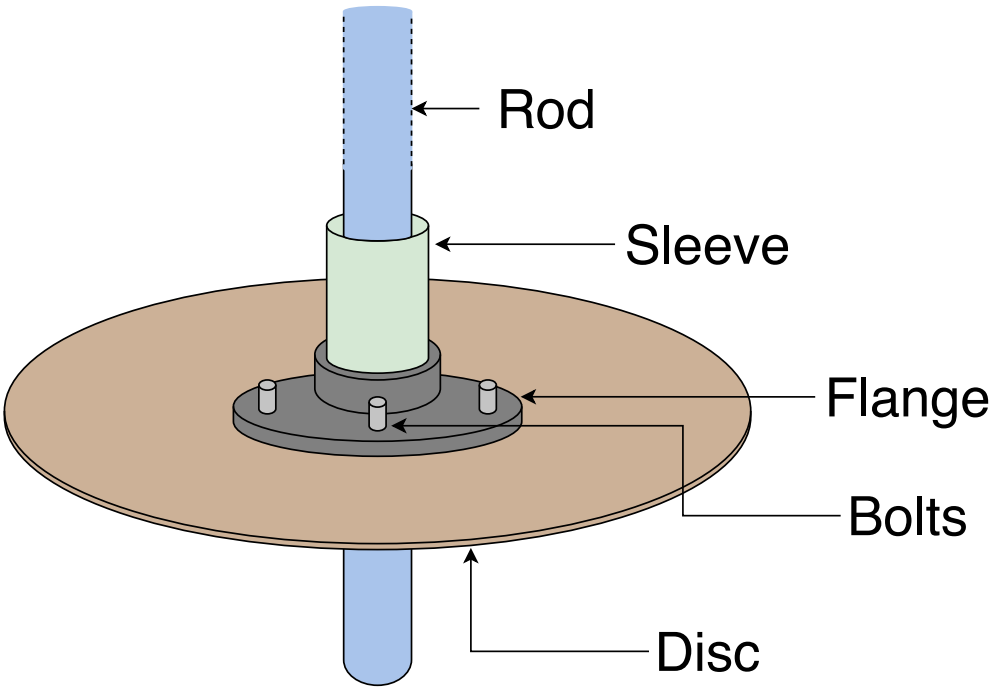

Figure 1: Schematic diagram of the DPM design described above.

3.1 Materials

- Sleeve
  - PVC pipe
  - Internal diameter - >36.6 mm (1.15")
  - External diameter - 40-41.4 mm
  - Length - 30 cm
- Rod
  - PVC pipe
  - External diameter - <36 mm
  - Length - 180 cm
- Flange
  - Full face flange PN10/PN16BR1
  - Internal diameter - 40 mm
- Disc
  - Plywood
  - Diameter - 45.8 cm
  - Thickness - 5 mm
- Nuts and bolts
  - x4
  - M16x70
- PVA Glue

3.2 Instructions

1. Cut the plywood to a disc and drill holes which line up with the flange.
2. Soak the plywood disc in PVA glue for an hour to apply waterproofing. Let the PVA dry completely.
3. Cut the sleeve pipe to a length of 30 cm.
4. Push the sleeve into the flange fitting. If the fit is loose, try packing the gap with glue.
5. Bolt the flange to the disc, with the bolts facing upwards.
6. Weigh the disc, flange, sleeve and bolts together. Add extra weights such as extra bolts as needed to reach 1.5 kg.
7. Thread the sleeve over the rod.

3.3 Usage

To use the DPM, slowly lower or drop the disc from a pre-determined height. Ensure that the rod is held vertical, but don't shake the rod as the disc is settling. After the disc has settled, read off the height of the disc.

To allow quick measurement of the disc height, consider etching 5 cm marks into the rod. When the disc has settled, hold your thumb on the rod where the top of the sleeve reaches, then remove the rod and count the number of 5 cm marks from the bottom of the rod. When back in the lab, apply a correction factor by subtracting the distance between the disc and the top of the sleeve from the height measurement to get the height of the disc.

To build the disc height-biomass allometry, clip living biomass to ground level at a subset of DPM samples, using a pair of secateurs, shears, or sickles. Make sure to discard litter found near the ground. Begin by clipping all material in a radius around the DPM disc to improve visual clarity of what material should be sampled. Consider using a 'sampling cylinder' of the same diameter as the disc to make it easier to see what grass material should be harvested. Sampling cylinders can

be made from a strip of acrylic plastic folded into a cylinder. Alternatively I have used a flexi-tub, also known as a rubble bucket, with the base cut off.

References

Aiken, G.E. and D.I. Bransby (1992). "Observer Variability for Disk Meter Measurements of Forage Mass". In: *Agronomy Journal* 84.4, pp. 603–605. DOI: 10.2134/agronj1992.00021962008400040012x.

Bareth, Georg and Jürgen Schellberg (2018). "Replacing Manual Rising Plate Meter Measurements with Low-cost UAV-Derived Sward Height Data in Grasslands for Spatial Monitoring". In: *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 86.3-4, pp. 157–168. DOI: 10.1007/s41064-018-0055-2.

Bransby, D.I. and N.M. Tainton (1977). "The disc pasture meter : Possible applications in grazing management". In: *Proceedings of the Annual Congresses of the Grassland Society of Southern Africa* 12.1, pp. 115–118. DOI: 10.1080/00725560.1977.9648818.

Brenner, Fred J. et al. (1994). "Evaluation of procedures to estimate biomass on surface coal mine lands reclaimed under the Surface Mining Control and Reclamation Act of 1977". In: *Environmental Management* 18.2, pp. 307–315. DOI: 10.1007/bf02393771.

Brockett, B.H. (1996). "Research note: Calibrating a disc pasture meter to estimate grass fuel loads on the Zululand coastal plain". In: *African Journal of Range & Forage Science* 13.1, pp. 39–41. DOI: 10.1080/10220119.1996.9647892.

Bryan, W. B., W. V. Thayne, and E. C. Prigge (1989). "Use of a Disk Meter to Evaluate Continuously Grazed Pastures". In: *Journal of Agronomy and Crop Science* 163.1, pp. 44–48. DOI: 10.1111/j.1439-037x.1989.tb00735.x.

Castle, M. E. (1976). "A simple disc instrument for estimating herbage yield". In: *Journal of the British Grassland Society* 31, pp. 31–40.

Charles-Dominique, Tristan et al. (2018). "Steal the light: shade vs fire adapted vegetation in forest-savanna mosaics". In: *New Phytologist* 218.4, pp. 1419–1429. DOI: 10.1111/nph.15117.

Coller, Helga Van, Frances Siebert, and Stefan J. Siebert (2013). "Herbaceous species diversity patterns across various treatments of herbivory and fire along the sodic zone of the Nkuhlu exclosures, Kruger National Park". In: *Koedoe* 55.1. DOI: 10.4102/koedoe.v55i1.1112.

Cooper, Sam et al. (2017). "Examination of the Potential of Terrestrial Laser Scanning and Structure-from-Motion Photogrammetry for Rapid Nondestructive Field Measurement of Grass Biomass". In: *Remote Sensing* 9.6, p. 531. DOI: 10.3390/rs9060531.

Danckwerts, J.E. and W.S.W. Trollope (1980). "Assessment of the disc pasture meter on natural veld in the false thornveld of the eastern province". In: *Proceedings of the Annual Congresses of the Grassland Society of Southern Africa* 15.1, pp. 47–52. DOI: 10.1080/00725560.1980.9648884.

Dörgeloh, Werner G. (2002). "Calibrating a disc pasture meter to estimate above-ground standing biomass in Mixed Bushveld, South Africa". In: *African Journal of Ecology* 40.1, pp. 100–102. DOI: 10.1046/j.0141-6707.2001.00338.x.

Dougherty, Mark et al. (2013). "Calibration and use of plate meter regressions for pasture mass estimation in an Appalachian silvopasture". In: *Archives of Agronomy and Soil Science* 59.2, pp. 305–315. DOI: 10.1080/03650340.2011.615026.

Earle, DF and AA McGowan (1979). "Evaluation and calibration of an automated rising plate meter for estimating dry matter yield of pasture". In: *Australian Journal of Experimental Agriculture* 19.98, p. 337. DOI: 10.1071/ea9790337.

February, Edmund C. et al. (2013). "Influence of competition and rainfall manipulation on the growth responses of savanna trees and grasses". In: *Ecology* 94.5, pp. 1155–1164. DOI: 10.1890/12-0540.1.

Fehmi, J. S. and J. M. Stevens (2009). "A plate meter inadequately estimated herbage mass in a semi-arid grassland". In: *Grass and Forage Science* 64.3, pp. 322–327. DOI: 10.1111/j.1365-2494.2009.00694.x.

Fushai, F.M. (2006). "Estimates of intake and digestibility using n-alkanes in yearling Holstein-Friesian and Hereford heifers grazing on kikuyu (Pennisetum clandestinum) pasture". In: *Animal Feed Science and Technology* 128.3-4, pp. 331–336. DOI: 10.1016/j.anifeedsci.2005.11.006.

Ganguli, Amy C. et al. (2000). "Comparison of Four Nondestructive Techniques for Estimating Standing Crop in Shortgrass Plains". In: *Agronomy Journal* 92.6, pp. 1211–1215. DOI: 10.2134/agronj2000.9261211x.

Gwate, Onalenna et al. (2021). "The effects of Acacia mearnsii (black wattle) on soil chemistry and grass biomass production in a South African semi-arid rangeland: implications for rangeland rehabilitation". In: *African Journal of Range & Forage Science*, pp. 1–11. DOI: 10.2989/10220119.2021.1875048.

Hardy, M.B. and M.T. Mentis (1985). "The relative efficiency of three methods of estimating herbage mass in veld". In: *Journal of the Grassland Society of Southern Africa* 2.1, pp. 35–38. DOI: 10.1080/02566702.1985.9647996.

Harmoney, Keith R. et al. (1997). "Determination of Pasture Biomass Using Four Indirect Methods". In: *Agronomy Journal* 89.4, pp. 665–672. DOI: 10.2134/agronj1997.00021962008900040020x.

Harmse, Christiaan J, Niels Dreber, and Winston SW Trollope (2019). "Disc pasture meter calibration to estimate grass biomass production in the arid dunefield of the south-western Kalahari". In: *African Journal of Range & Forage Science* 36.3, pp. 161–164. DOI: 10.2989/10220119.2019.1610905.

Little, Ian T., Philip A.R. Hockey, and Raymond Jansen (2015). "Impacts of fire and grazing management on South Africa's moist highland grasslands: A case study of the Steenkampsberg Plateau, Mpumalanga, South Africa". In: *Bothalia* 45.1. DOI: 10.4102/abc.v45i1.1786.

McSweeney, D. et al. (2019). "Micro-sonic sensor technology enables enhanced grass height measurement by a Rising Plate Meter". In: *Information Processing in Agriculture* 6.2, pp. 279–284. DOI: 10.1016/j.inpa.2018.08.009.

Nieto-Quintano, Paula et al. (2018). "The mesic savannas of the Bateke Plateau: carbon stocks and floristic composition". In: *Biotropica* 50.6, pp. 868–880. DOI: 10.1111/btp.12606.

Palazzo, A. J. and C. R. Lee (1986). "Biomass determination at reclamation sites using a weighted disk meter". In: *Reclamation & revegetation research* 4.4, pp. 307–312.

Phillips, D.S.M. and S.E. Clarke (1971). "THE CALIBRATION OF A WEIGHTED DISC AGAINST PASTURE DRY MATTER YIELD". In: *Proceedings of the New Zealand Grassland Association*, pp. 68–75. DOI: 10.33584/jnzg.1971.33.1308.

Powell, T. L. (1974). "Evaluation of weighted disc meter for pasture yield estimation on intensively stocked dairy pasture". In: *New Zealand Journal of Experimental Agriculture* 2.3, pp. 237–241. DOI: 10.1080/03015521.1974.10427682.

Randle, M., N. Stevens, and G. Midgley (2018). "Comparing the differential effects of canopy shading by Dichrostachys cinerea and Terminalia sericea on grass biomass". In: *South African Journal of Botany* 119, pp. 271–277. DOI: 10.1016/j.sajb.2018.09.026.

Rayburn, E. and J. Lozier (2003). *Estimating pasture forage mass from pasture height. Fact Sheet.* Morgantown WV, USA: West Virginia University Extension Service.

Rayburn, Edward B. and Susan B. Rayburn (1998). "A Standardized Plate Meter for Estimating Pasture Mass in On-Farm Research Trials". In: *Agronomy Journal* 90.2, pp. 238–241. DOI: 10.2134/agronj1998.00021962009000020022x.

Santillan, R. A., W. R. Ocumpaugh, and G. O. Mott (1979). "Estimating Forage Yield with a Disk Meter 1". In: *Agronomy Journal* 71.1, pp. 71–74. DOI: 10.2134/agronj1979.00021962007100010017x.

Sharrow, Steven H. (1984). "A Simple Disc Meter for Measurement of Pasture Height and Forage Bulk". In: *Journal of Range Management* 37.1, p. 94. DOI: 10.2307/3898833.

Teague, W. R. et al. (1996). "Increasing Utilization Efficiency of Continuously Stocked Old World Bluestem Pasture". In: *Journal of Range Management* 49.6, p. 535. DOI: 10.2307/4002295.

Thrash, I. (1998). "Impact of water provision on herbaceous vegetation in Kruger National Park, South Africa". In: *Journal of Arid Environments* 38.3, pp. 437–450. DOI: 10.1006/jare.1997.0318.

Trollope, W S W and A L F Potgieter (1986). "Estimating grass fuel loads with a disc pasture meter in the Kruger National Park". In: *Journal of the Grassland Society of Southern Africa* 3.4, pp. 148–152. DOI: 10.1080/02566702.1986.9648053.

Vartha, E. W. and A. G. Matches (1977). "Use of a Weighted-disk Measure as an Aid in Sampling the Herbage Yield on Tall Fescue Pastures Grazed by Cattle". In: *Agronomy Journal* 69.5, pp. 888–890. DOI: 10.2134/agronj1977.00021962006900050042x.

Veen, G. F., Elzemiek Geuverink, and Han Olff (2011). "Large grazers modify effects of above-ground–belowground interactions on small-scale plant community composition". In: *Oecologia* 168.2, pp. 511–518. DOI: 10.1007/s00442-011-2093-y.

Virkajäarvi, P. (1999). "Comparison of Three Indirect Methods for Prediction of Herbage Mass on Timothy-Meadow Fescue Pastures". In: *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science* 49.2, pp. 75–81. DOI: 10.1080/09064719950135579.

Zambatis, N et al. (2006). "Re-evaluation of the disc pasture meter calibration for the Kruger National Park, South Africa". In: *African Journal of Range & Forage Science* 23.2, pp. 85–97. DOI: 10.2989/10220110609485891.