Photographic evidence of seasonal change in a secondary form on a 'complex' linear dune.

by

Ian Livingstone
School of Environmental Studies, Gloucestershire College of Arts and Technology, Oxstalls Lane, Gloucester, GL2 9HW, U.K.

Present address:
Department of Geography,
Coventry Polytechnic,
Priory Street,
Coventry, CV 1 5FB, U.K.

ABSTRACT

As part of a wider study of linear dune dynamics, a series of photographs were taken of a secondary, barchanoid form on a 'complex' linear dune in the Namib Desert at regular intervals over one year from a strategic picket. These photographs show the response of the secondary dune to a seasonal wind regime. During the summer months this secondary dune's slip face faced north-east under the influence of a south-westerly regime, and in winter faced west as a consequence of an easterly wind regime. The nature of this response has repercussions for models which attempt to explain linear dune dynamics.

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1 INTRODUCTION

Although linear dunes (also known as longitudinal and seif dunes) dominate the world's deserts, there have been few empirical studies of the dynamics of linear dune origin and maintenance. Consequently, a field investigation of the geomorphological dynamics of a 'complex' linear dune in the Namib sand sea was undertaken between 1980 and 1982 (Livingstone 1985). As part of that study, photographs were taken at regular intervals from strategic pickets as a qualitative support to other quantitative techniques being used simultaneously. In particular, the development of a secondary feature on the flank of the main study dune was monitored, and it is this photographic evidence which is presented here.

2 METHOD AND RESULTS

The site for this study of the dynamics of a single linear dune lies at the northern edge of the Namib sand sea in southern Africa, approximately eight kilometres south-east of the Namib Research Institute at Gobabeb (23°34'S, 15°03'E). The dune, known at the research station as Visitors' Dune, is aligned roughly north-south at the study site, and is approximately 350 metres wide and 50 metres high. The site was chosen as here the dune displays the asymmetry typical of linear dunes in this part of the Namib Desert, with a relatively uniform west flank, but a series of secondary ridges and barchanoid features on the east flank. Because of these secondary dunes and its size, this is a 'complex' dune in the terminology of McKee (1979) and Lancaster (1982), and a 'draa' in the terminology of Wilson (1972).

The central Namib Desert is subject to a seasonal wind regime so that, broadly speaking, the dunes are attacked by low to moderate strength winds from the south-west and north-west in summer, and by high magnitude, low frequency easterly winds in winter (Lancaster *et al.* 1984). The dunes in this area extend northward along the line of resolution of the vectors of wind speed and direction into the bed of the ephemeral Kuiseb River at a rate measured by Ward

(1984) of between 0 and 1.85 m yr^{-1}. The crest of the dune oscillates back and forth laterally some fourteen metres each year, but there appears to be no measurable lateral movement of the position of the dune base (Livingstone 1985).

To measure the dynamic patterns of surface change on the dune, a grid of steel posts was established in 1980 and measured every week for four years (1980-1984), thus providing a considerable body of quantitative information about the changes of dune form. As a complement to this quantitative method, photographs were taken at regular intervals from strategic pickets. Plates 1 to 8 are all taken from the same strategic picket, and show the development of a secondary dune feature on the east flank of the parent dune between October 1980 and August 1981. In all the photographs the camera is facing towards the south-west. Figure 1 plots the development of the same secondary dune using information from the measurements of the steel posts.

During summer when the dune field is subjected to south-westerly winds on almost every afternoon, the secondary dune progresses towards the north-east (towards the camera) under the influence of these winds. It develops a slip face of its own quite separate from the main slip face on the parent dune seen at the top of the photographs. When the easterly winds of winter first arrive (in late May in 1981), this alignment normal to the south-westerly winds is destroyed (plate 6), and with more easterly winds during winter a new slip face is created normal to the easterly winds (plates 7 and 8). Although not illustrated here, the return to the summer regime of south-westerly winds brings a re-alignment of the slip face perpendicular to the south-westerly wind. The series of photographs thus illustrates a very marked pattern of landform development related to the seasonal nature of the wind regime.

3 DISCUSSION

The behaviour of this secondary, barchanoid form on the flank of a 'complex' linear dune has crucial repercussions in the discussion of linear dune dynamics. Following his important pioneering study of a simple linear dune in the Negev Desert, Israel, Tsoar has proposed that,

> "The basis of the dynamics of the longitudinal dune is the phenomenon that the path of the wind flow when crossing the crest at any angle whatsoever is deflected on the lee flank in the direction parallel to the crest line." (Tsoar 1978, p.133).

Tsoar's argument is that the intrusion of the dune into the atmospheric boundary-layer creates a lee side eddy such that sand transport is predominantly along the dune, and sand is prevented from leaving the dune. Two conditions must be fulfilled for this mechanism to operate: there must be a bi-directional wind regime, and the dune must have a sharp crest line so that flow separation occurs in the immediate lee of the crest (Tsoar 1978: 1983).

Providing it is accepted that this secondary feature on Visitors' Dune demonstrates a transverse relationship to the formative wind, its progress towards the north-east under the influence of south-westerly winds in summer suggests that any influence of a lee side eddy does not reach this far down the parent dune's lee flank. This is confirmed in wind flow studies which show that the lee side eddy does exist, but that it is restricted to the upper lee slope where the main slip face is formed (Livingstone 1985: 1986). Indeed, the lee side eddy on this dune in south-westerly winds is of much the same magnitude as that described by Tsoar (1978), but while an eddy of this size covers the entire lee flank on a 'simple' linear dune such as Tsoar's which is between 6 and 13 metres high, it controls only the upper slope of a 'complex' dune such as that in the present study.

This evidence from the development of a secondary dune for a recovery of the incident wind direction at some point on the lee flank of 'complex' dunes is supported from other parts of the investigation. Wind speed measurements, flow visualisation using smoke flares, erosion pin measurements, sand traps and personal observation suggest that Tsoar's model of maintenance of linear dune from by secondary wind flow created by the dune's intrusion into the boundary-layer may not have universal applicability. Elsewhere, the present author has offered an alternative model of linear dune dynamics based on wind speeds over the dune cross-profile (Livingstone 1986).

4 CONCLUSION

The photographs taken during this project have provided a valuable, readily appreciated, graphic support to other quantitative methods used in the study, particularly the steel post measurements. They have helped in monitoring the development of a secondary dune form in a seasonal wind regime, and the findings from this technique, when combined with other evidence, have important implications for the understanding of the dynamics of linear dunes. In particular, it apears that a model such as Tsoar's (1978: 1983) invoking a lee side eddy covering the entire lee flank is not supported by the evidence of the development of the secondary dune forms on linear dunes of this size. It is therefore necessary to look elsewhere for an explanation of the dynamic mechanism of linear dune maintenance for the larger 'complex' dunes.

Clearly, there remains considerable scope for further investigation along the lines of this study and Tsoar's, and much can still be learnt from careful field studies

Plate 1: Week 2, 24.10.80

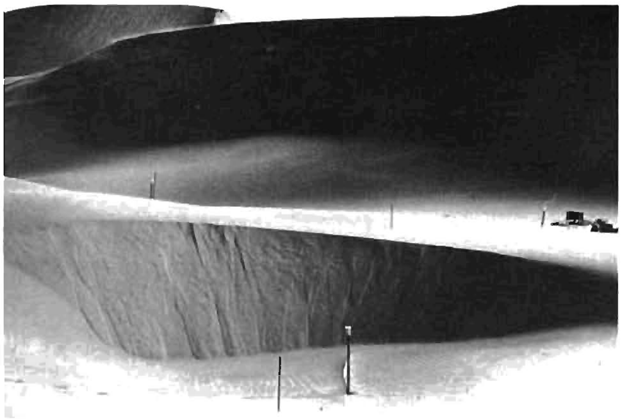

Plate 2: Week 5, 18.11.80

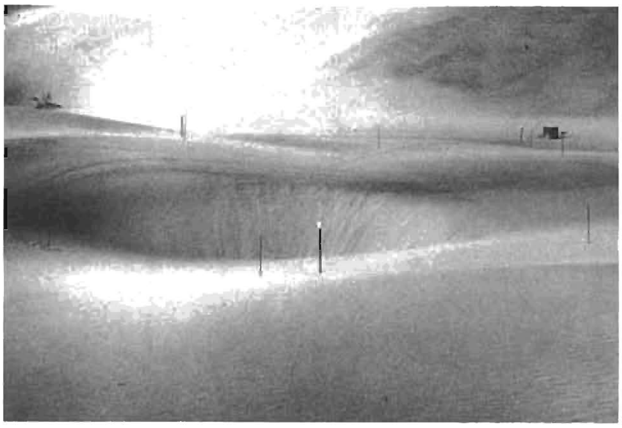

Plate 3: Week 10, 18.12.80

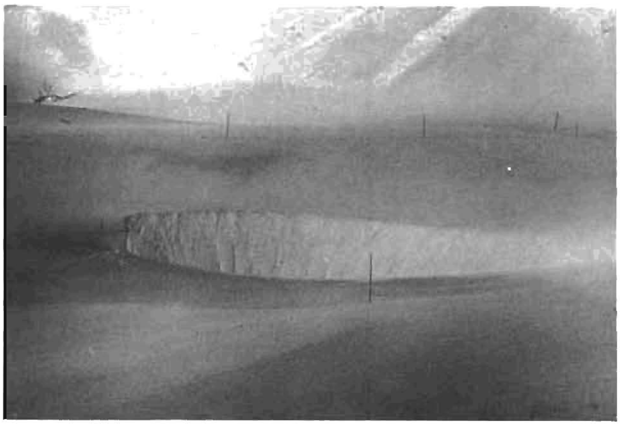

Plate 4: Week 24, 27.3.81

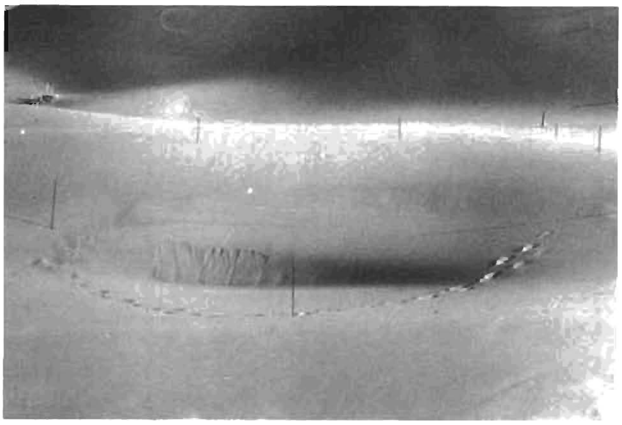

Plate 5: Week 29, 4.5.81

Plate 6: Week 33, 3.6.81

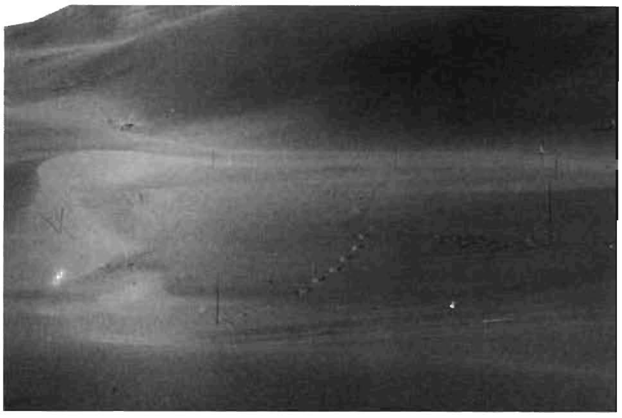

Plate 7: Week 38, 6.7.81

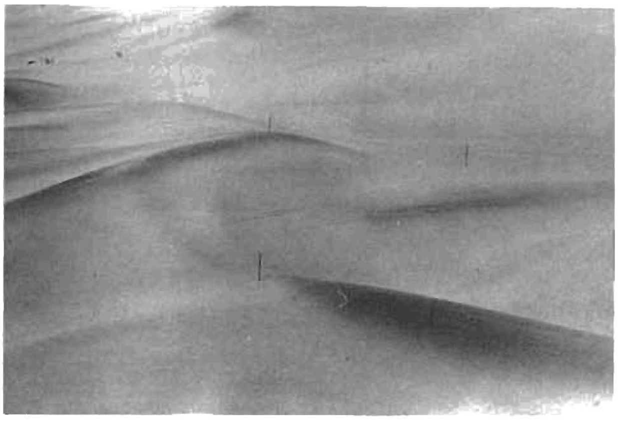

Plate 8: Week 43, 10.8.81

PLATES: Strategic picket photography of the secondary dunes on the east flank of Visitors' Dune.

of individual dunes. It is possible that the linear dune will prove to be an equifinal form - the result of a number of different causes - and that no one comprehensive model will be applicable to all linear dunes.

5 ACKNOWLEDGEMENTS

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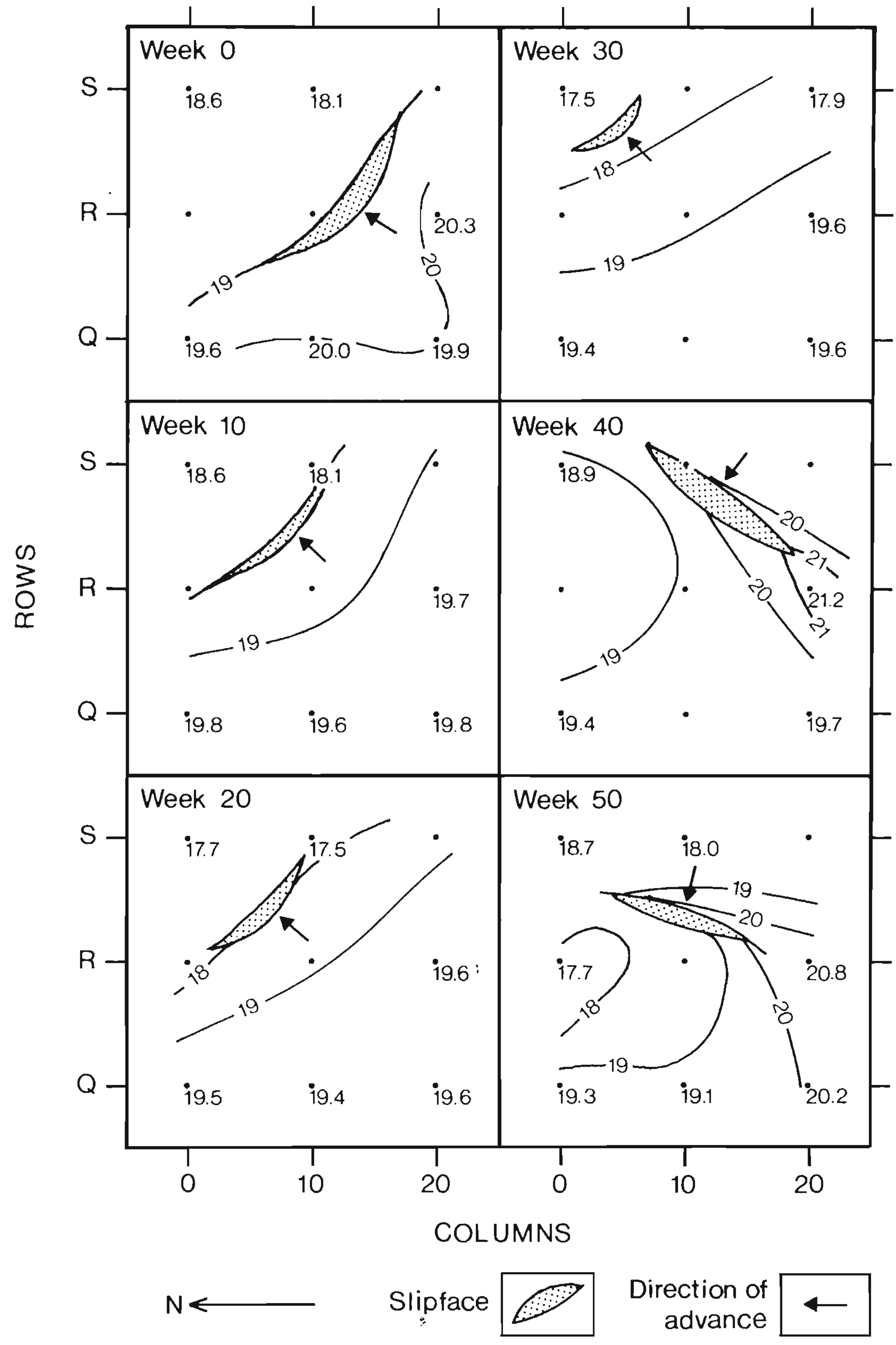

FIGURE 1: Plans of the secondary dunes on the east flank of Visitor's Dune at ten week intervals (Week 0 = 15.10.80). Spot heights are for points on a 10 metre grid marked by the steel posts. Contours and spot heights are given in metres above an arbitrary datum.

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