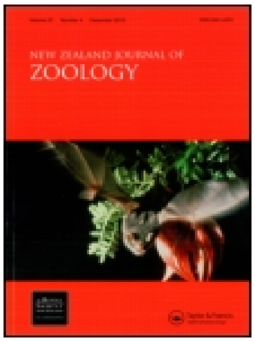

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New Zealand Journal of Zoology

ISSN: 0301-4223 (Print) 1175-8821 (Online) Journal homepage: http://www.tandfonline.com/loi/tnzz20

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To cite this article: Neil F. Hadley , Thomas D. Schultz & Anthony Savill (1988) Spectral reflectances of three tiger beetle subspecies (Neocicindela perhispida): Correlations with their habitat substrate, New Zealand Journal of Zoology, 15:2, 343-346, DOI: 10.1080/03014223.1988.10422624

To link to this article: http://dx.doi.org/10.1080/03014223.1988.10422624

New Zealand Journal of Zoology, 1988, Vol. 15: 343–346
0301–4223/88/1502–0343$2.50/0

Short communication

Spectral reflectances of three tiger beetle subspecies (*Neocicindela perhispida*): correlations with their habitat substrate

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Abstract The coloration and cuticular reflec-tivity of the three subspecies of the tiger beetle *Neocicindela perhispida*, that occur along coastal beaches of the North Island of New Zealand, were examined. The hardened forewings (elytra) of all three subspecies exhibited colour patterns that matched the sand of their respective beach habitats. The dark *N. p. campbelli*, which occurs on black ironsand beaches, absorbed significantly higher amounts of solar radiation than *N. p. giveni* whose white elytra blended well with the white quartz sands on which it occurred. The mottled *N. p. perhispida*, which inhabits yellowish-brown beaches, exhibited reflectivities generally intermediate to these two extremes.

Keywords tiger beetles; *Neocicindela perhispida*; coloration; reflectivity

INTRODUCTION

Tiger beetles are excellent subjects upon which to test interrelationships between colour and insect biology. The dorsal surface of tiger beetles, especially the elytra, may be black, white, or brightly coloured. Moreover, elytral colour patterns often resemble closely the substrate upon which the beetles occur and may conceal them from visually hunting predators such as birds (Schultz 1986). Such is the case for the tiger beetle *Neocicindela perhispida*, found on beach sands along the western and northeastern coasts of the North Island of New Zealand. Three subspecies are recognised on the basis of their dorsal coloration: *N. p. campbelli* (Broun), a dark beetle found on black ironsand beaches; *N. p. perhispida* (Broun), a "mottled" beetle which occurs on yellowish-brown beaches; and *N. p. giveni* van Nidek, a white form which inhabits white quartz beach sands (van Nidek 1965).

In this study, we examined this species complex to establish how closely their dorsal colorations match the background by measuring the spectral reflectance of their elytra and that of their respective beach substrates.

COLLECTION SITES

Adult representatives of the three subspecies were collected on 19 November and 26–27 November 1986. *Neocicindela perhispida campbelli* were collected from Bethell's Beach, approximately 30 km west of Auckland; *N. perhispida perhispida* from Bayly's Beach, approximately 120 km north of Bethell's Beach; and *N. perhispida giveni* from Rarawa Beach, Great Expedition Bay, on the tip of the North Island. Individual beetles were immediately killed by exposure to ethyl acetate vapours, wrapped in tissue, placed in sealed vials, and ultimately returned to the United States for analysis. Samples of the beach sand (upper 1 cm) from each of the three sites were also obtained.

METHODS

Reflectivities of individual beetles and the sand on which they occur were measured by a Cary 2300 spectrophotometer with the "Praying Mantis" (PM)

Received 5 June 1987; accepted 17 December 1987

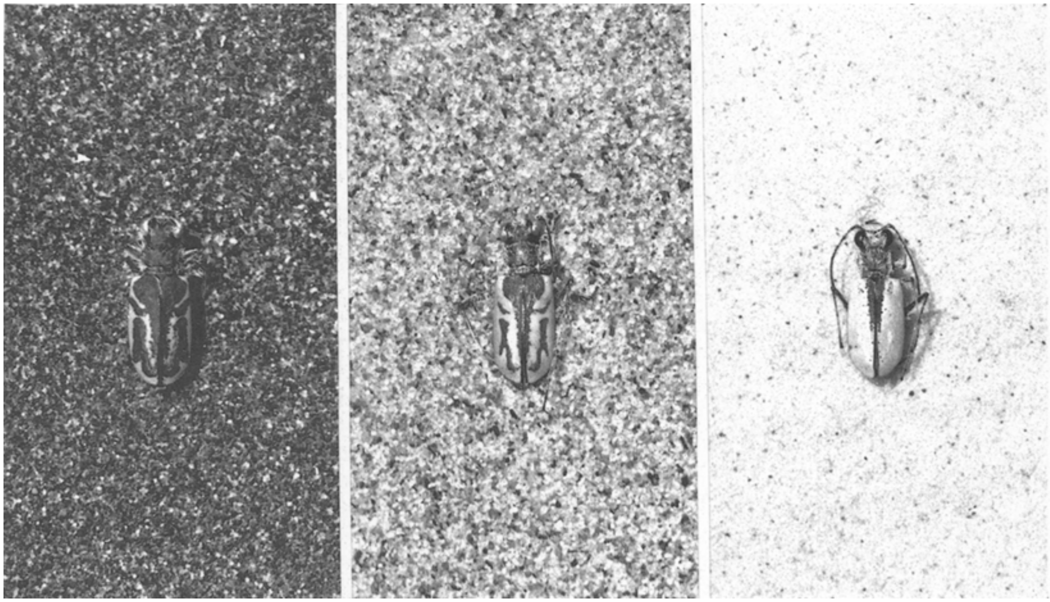

Fig. 1 Three subspecies of *Neocicindela perhispida* photographed on sand from their natural beach habitat: **left**, *N. p. campbelli*; **center**, *N. p. perhispida*; **right**, *N. p. giveni*.

Diffuse Reflectance Accessory (Varian Corp.). Beetle specimens and sand samples were mounted side by side at the same height on the sliding specimen holder with the PM accessory. Reflectances over a wavelength range of 250 to 2000 nm were measured sequentially from the elytra (area 4 mm in diameter) of a whole beetle and from the sand substrate. Total reflectances were obtained by comparing the raw data to that of a NBS Standard No. 2019B.

RESULTS

The coastal sands on which the three subspecies of *Neocicindela perhispida* occur are described in Schofield (1970) and Hamill & Ballance (1985). The dark sands at Bethell's Beach are rich in volcanic-derived heavy minerals, especially titanomagnetite ("ironsand"). Further north along the coast at Bayly's Beach, the sand consists of some dark mafic material (c. 10%) with the remainder composed of equal amounts of quartz and feldspar, giving it a lighter yellowish-brown colour. The white crystalline beaches to the far north are rich in silica (>95%), with Fe_2O_3 accounting for less than 0.1% of the mineral content.

The elytral coloration of each of the three beetle subspecies closely matches that of their respective sand substrate (Fig. 1). *N. p. campbelli* collected from the black sands of Bethell's Beach is very dark dorsally, and the thin white maculations on the elytra resemble the lighter elements of the sand in size and colour (Fig. 1, left). The approximately 35% dark green and 65% white elytral pattern of *N. p. perhispida* (Fig. 1, center) creates a mottled appearance that matches the lighter, mixed sands of Bayly's Beach. The elytra of *N. p. giveni* are entirely white except for a tapering dark border along the elytral midline. The head and pronotum of this subspecies is also densely covered with white setae. In some specimens, there is a posterior lateral dark streak, about one-third the length of the elytron. Although such dark patches may be larger than similar dark elements in the sand, the colour patches of the beetle and substrate mix or blend at a distance, making *N. p. giveni* very inconspicuous on the white sand beach (Fig. 1, right).

The spectral reflectivities of the beetles in the visible wavelengths (400–700 nm) closely match or parallel the reflectivities of their respective backgrounds (Fig. 2). The close similarity in the reflectance curves of *N. p. perhispida* and *N. p. campbelli* indicate they match their backgrounds in

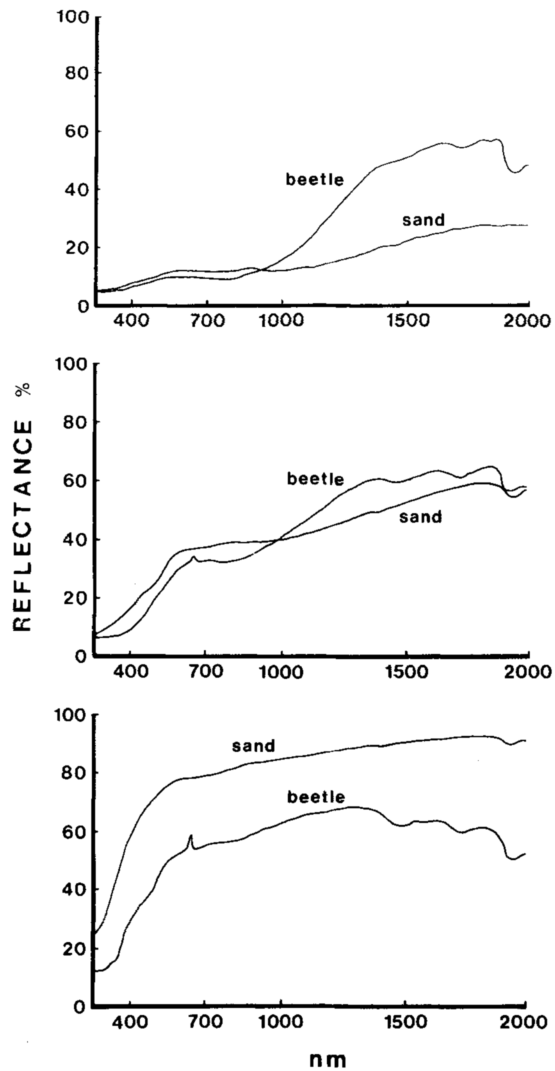

Fig. 2 Reflectivities of the three subspecies of *Neocicindela perhispida* and the sand from their natural beach habitat: **top,** *N. p. campbelli*; **middle,** *N. p. perhispida*; **bottom,** *N. p. giveni*.

both colour and brightness. *N. p. giveni* matches the relative spectral distribution of reflectance by the quartz sand, but it is considerably less reflective overall. However, the beetle may still be inconspicuous because saturation from a highly reflective substrate lessens the ability of visual systems to discriminate contrast in brightness (Norris 1967). The striking similarities in the measured spectral reflectivities between beetle and sand suggest that each subspecies is inconspicuous at some distance to any visual predator.

DISCUSSION

The colours and patterns that characterise the three subspecies of *Neocicindela perhispida* have a structural basis. They result from the reflection of light by multiple thin-layers in the outermost layer of the cuticle (see Schultz & Rankin 1985 for a detailed description of this mechanism in tiger beetles). The observed colour is caused by specific wavelengths of light being reflected at the interface of these layers and constructively interfering. In dull, mixed colours, such as the dark green patches of *N. p. campbelli*, the reflecting layers vary in thickness and orientation. The white or "maculated" areas that dominate the elytral surface of *N. p. giveni* contain no pigment or reflecting layers. In the absence of pigment, light of all wavelengths is scattered by non-absorptive structures in the cuticle, producing a structural white. The amount and arrangement of the pigmented material, which is secreted by the epidermis during ecdysis, is likely under genetic control (Schultz 1986).

Because of the flexible nature of this colour-producing system, distinct colour morphs that appropriately match different substrates can evolve within a tiger beetle species such as those described here for *N. perhispida*. The background matching abilities of these subspecies likely conceal them from visual predators; however, this adaptation is also likely accompanied by certain thermal costs. For example, *N. p. campbelli*, which occurs on the highly absorptive ironsands, is itself highly absorptive between 400 and 1000 nm and sustains considerably higher rates of short wave energy gain than the two lighter subspecies (Fig. 2). Studies designed to investigate the extent to which these functions are in conflict with one another are underway.

ACKNOWLEDGMENTS

We thank D. Cowley for kindly intoducing NFH to the Bethell's Beach population and assisting with the collection of *N. p. campbelli*. We also thank E. C. Young and the Zoology Department, University of Auckland, for generously providing space and facilities during NFH's sabbatical visit. M. Fisher and the Varian Corp. kindly provided the use of the Varian 2300 Reflectance Spectrophotometer. This study was supported by NSF Grant DCB-8601817 and a grant from the Scientific Research Committee of the New Zealand Lotteries Board and Canterbury Museum Trust Board.

REFERENCES

Hamill, P. F.; Ballance, P. F. 1985: Heavy mineral rich sands of the Waitakere coast, Auckland, New Zealand. *New Zealand journal of geology and geophysics 28*: 503–511.

Norris, K. S. 1967: Color adaptation in desert reptiles and its thermal relationships. *In*: Milstead, W. W. *ed.*, Lizard ecology: a symposium. Columbia, Missouri, University of Missouri Press. pp. 162–229.

Schofield, J. C. 1970: Coastal sands of northland and Auckland. *New Zealand journal of geology and geophysics 13*: 767–824.

Schultz, T. D. 1986: Role of structural colors in predator avoidance by tiger beetles of the genus *Cicindela* (Coleoptera: Cicindelidae). *Bulletin of the Entomological Society of America 32*: 142–146.

Schultz, T. D.; Rankin, M. A. 1985: The ultrastructure of the epicuticular interference reflectors of tiger beetles (*Cicindela*). *Journal of Experimental Biology 117*: 87–110.

van Nidek, C. B. 1965: Cicindelidae of New Zealand with descriptions of a new species and subspecies. *New Zealand journal of science 8*: 352–358.