National Research Council Canada
Conseil national de recherches Canada

FIELD NOTE NO. 73

EFFECTS OF INTERRUPTED LIGHT ON BIRDS

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OCTOBER 1976

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In the belief that rapid exchange of information is of the utmost importance to a solution of the bird problem, the Associate Committee on Bird Hazards to Aircraft has decided to release rough field notes as soon as they are produced, rather than to wait until these data would normally appear in formal reports.

These field notes are produced for information and will not usually receive the editorial care given to formal reports.

It is hoped that other groups will contribute similar notes on an exchange basis.

V. E. F. Solman

V.E.F. Solman, Chairman
Associate Committee on
Bird Hazards to Aircraft.

ABSTRACT

Daytime field tests of stationary continuous incandescent and xenon-filled stroboscopic lights flashed at 2 - 20Hz show deterrent effects on gulls at feeding stations. With energies of 2 - 100 Watt-sec and with or without red, green, blue, cyan, magenta or yellow broadband filters, Gulls, European Starlings and Pigeons in the field showed no signs of distress or alarm and could not be dispersed from feeding sites.

Several field anaesthetics were evaluated during this phase of the project and "super 8mm" cine records were made of behaviour.

In the laboratory, stroboscopic lamps with a range of intensity and wavelength similar to those used in the field had marked effects on the pupils and electrical activity of the mid- and forebrain of all three species of bird. Under no conditions were seizures induced in normal birds although the bird-control compound "Avitrol" consistently produced seizures in all species (as well as in insects and mammals) that could be triggered by light and sound.

Electrodes were implanted successfully in the brains of 31 birds. They were routinely tested with flashes of 5 different intensities and up to six different colours. Up to three flashes were fired sequentially in a horizontal or vertical array.

The "frequency response" of the mid- and forebrain was investigated in all birds, using Fourier analysis of the brain waves evoked by flashes at 2 - 60Hz with and without colour filters.

The frequency and colour producing the most electrical activity varied from bird to bird and, in a single bird, different regions of the brain varied in their colour and frequency sensitivity.

Of fifteen birds analysed in detail 24% of the electrode insertions showed maximal responses to red and 24% to magenta 20% were yellow and

13% white sensitive. The remaining 15% responded maximally to blue, green or cyan.

The maximal driving frequency for the same birds ranged from 2-12Hz and its forebrain was often more active with lower frequency flashes than the midbrain. The midbrain of gulls had a mean optimum driving frequency of 9Hz, significantly higher than pigeons (6Hz) or starlings (5Hz).

Pen recordings of all experiments and computer derived averages and Fourier transforms have been stored and will be analysed in greater detail for publication later this year.

Brains of gulls and starlings have been preserved and are being sectioned to provide essential anatomical details for publication and future electrophysiological investigations.

A bibliography of colour vision, relevant electrophysiology and anatomy and behavioural observations on the effect of light on birds is appended.

A list of equipment that can be used in future reserach is also attached.

Behavioural Tests

Approximately one month was spent in the field observing gulls, starlings and pigeons.

Gulls were observed at a feeding station and their approach timed with or without an aircraft strobe (Heathkit OL 1155) present. There appeared to be a delay of 30-45 min before the birds approached the feeding tray with an unfiltered or magenta flash at 2/sec. The delay was not obviously different if the birds triggered the flash as they approached the feeding station compared with tests when the flash ran continuously.

There was no feeding during two four hour tests when a sound was triggered synchronously with the flash. The sound was a synthesized square wave of 2 sec duration falling in frequency from 2 KHz to 500Hz and to the human ear was similar to a starling's distress cry. Both flash and sound were triggered by movement near the feeding station using a Heathkit ultrasonic intrusion detector.

Some gulls were collected in this period using a mixture of Valium and Chloral hydrate in a 1:10 ratio by weight as a field anaesthetic.

100 mg of the mixture was inserted in cubes of processed cheese and distributed with untreated cheese. One glaucus-winged and one mew gull were relaxed enough to collect by hand after 15 min. in one test.

Laboratory tests showed that this mixture had a much higher safety factor than Nembutal administered orally, and that it was also effective on pigeons and starlings at doses of 50-500 mg/Kg.

I am indebted to Mr. W. G. Hébert of Environment Canada for suggesting the drug mixture and to Dr. N. Verbeek of Biological Sciences, S.F.U. for advice on baiting gulls.

Tests with a variable frequency (2-25Hz) 2 joule stroboscope, an 80w quartz iodide spotlight and sunlight reflected from a 10cm mirror were also carried out. None of these stimuli appeared to alarm or distress feeding, sitting or flying gulls, pigeons or starlings, although the immediate reaction of most birds was to look toward the light.

Single flashes from more intense lights (up to 100 j) apparently had no effect on these three species of bird.

Rapidly flashing lights at high intensities have not been tested. A large flash is being developed with the collaboration of S.F.U. physics department and should be ready for testing later this year.

Electrophysiological Tests

Methods.

Standard techniques were used to insert stainless steel electrodes into the brain. Insulated electrodes were normally inserted into the left and right optic tecta (midbrain) and the left and right wulsts (forebrain). An uninsulated reference electrode was inserted in the mid-line anterior to the brain.

Birds were anaesthetised with intravenous or intraperitoneal Nembutal or with Halothane by inhalation during the operation.

Birds were restrained in an elastic stocking or bandage during the tests and their heads fixed in position with a perspex neck and beak holder. The holder was aligned inside a bronze-mesh shielded enclosure with a battery of stroboscopes and electrical activity was recorded on a Grass model 7 polygraph with four channels, connected to a Digital Equipment PDP 12 minicomputer.

Standard signal averaging techniques were used to record the responses in the brain to two sets of 32 flashes at up to 5 different intensities with up to 6 different colour filters. Three General Radio Stroboslave flashes, triggered by a multiflash generator were fired in succession in 4 different "directions" (front to rear, rear to front, above to below and, below to above); two flashes were fired at increasing intervals of 20-160 mSec and for some birds one of these flashes was filtered.

Standard Fourier transform techniques were used to investigate "driving" of the brain activity using 3 Stroboslaves flashed synchronous: at frequencies between 1 and 60Hz. Up to 6 subsequent tests were run on each bird using colour filters in front of the flashes at frequencies between 2 and 20Hz.

All averages and transforms were stored on computer tapes, and samp: plots from them are included in the results section. It has not been po: to measure the main parameters of nearly 1,000 averages in the time avai: but a computer programme that can make such measurements has been obtain Unfortunately the arithmetic card needed to run the programme has not yet been delivered by Digital Equipment.

Results

Fourier transforms of brain activity from the mid and forebrain of the three species (P 15,pigeon, Gull H and S 5,starling) were variable as shown in the accompanying figures. Frequencies found in the brain activity were mostly below 20Hz and the range between 2 and 20 was plotted as a bar graph against the percentage of total power in the brain waves. The upper bar graph indicates the percentage of power at twice the flash frequency (harmonic driving) and in some instances flashes at, for example, 4Hz would produce brain activity at 4,8,12 and higher harmonic frequencies.

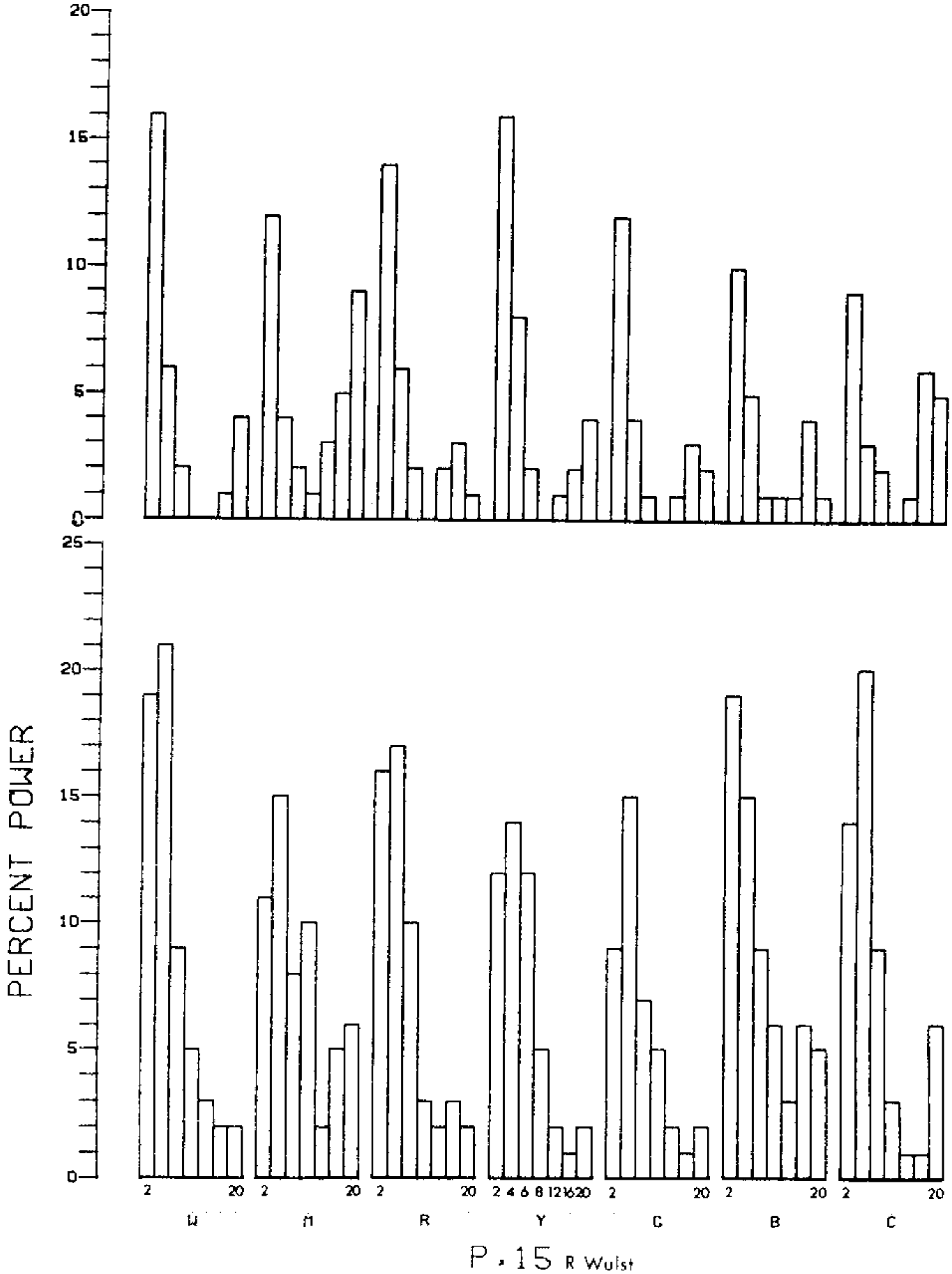
There is evidently no "colour" orflash frequency that can be singled out as most effective in influencing the brainwaves even within a species Colours can be ranked for each bird to allow for comparison, and some significant trends are apparent when this is done.

Table 1 shows the most effective colour for the two brain regions of each bird with the highest ranked colour for each species. The mean optimum flash frequency was also calculated for each region of each bird, regardless of colour.

In general the optimum driving frequency is higher in the optic tectum than in the forebrain. For the birds listed in table 1,these frequencies are 6Hz for the tectum and 4Hz for the forebrain. Colour is known to be discriminated in the optic tectum, so that some of the variability in colour optima in this region is probably caused by differences in the precise locations of the electrodes. Blue, green and cyan (minus red) are most effective on only one bird whereas red and magenta (minus green) are both most effective on three. Yellow (minus blue) and the unfiltered flashes (white) are most effective on two birds. The same trend is apparent in the forebrain, where colour discrimination has not been demonstrated before. Yellow is evidently the most effective colour for starlings, and magenta, although not the most effective colour for any individual gull,had the highest overall ranking for this species. Disregarding the location of the electrodes and species, magenta and yellow were the two most effective colours, whereas the two least effective were blue and cyan.

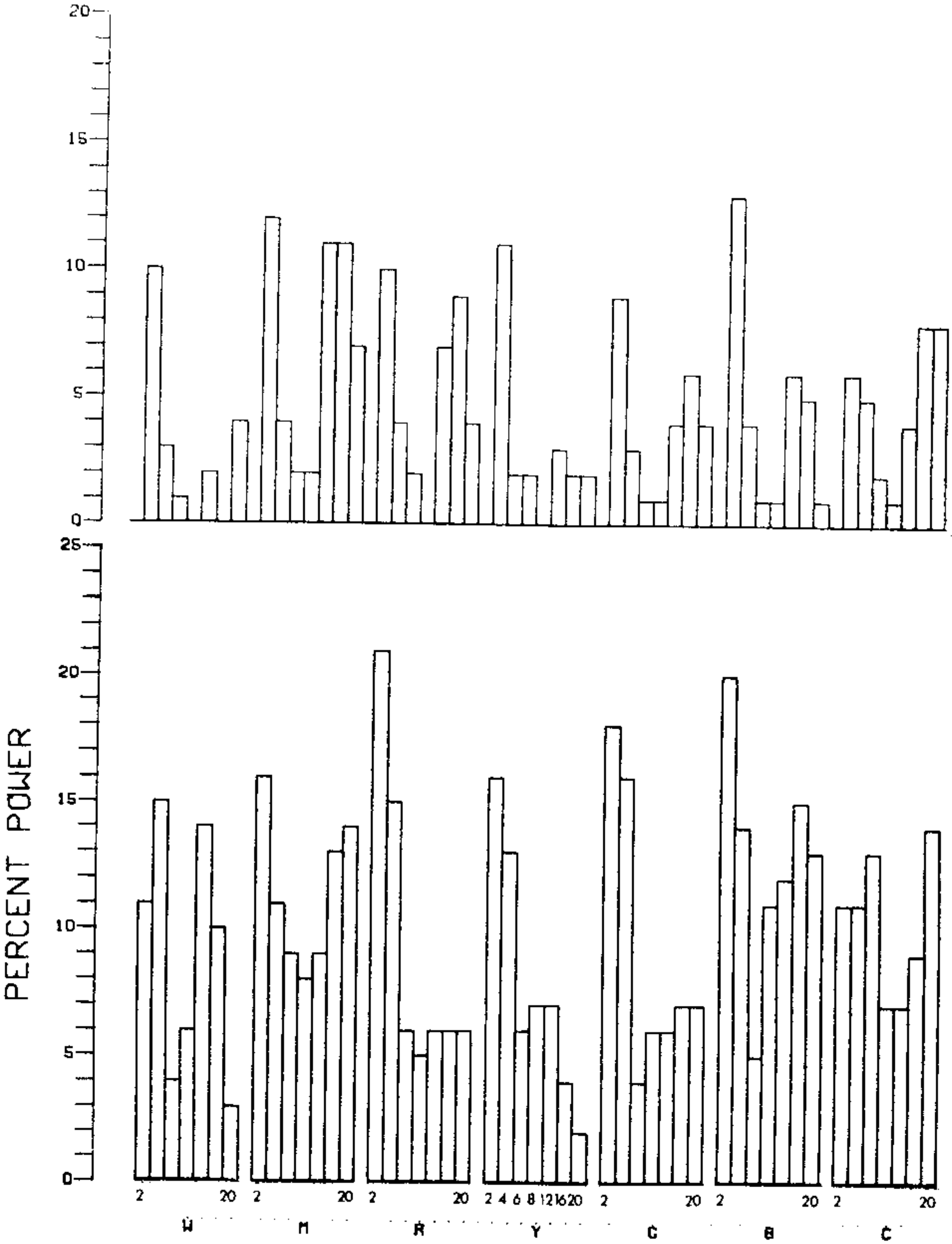
Bird	Tectum		Forebrain	
	Colour	Frequency	Colour	Frequency
P 14	Magenta	11 ± 5	Magenta	4 ± 0
P 15	Red	5 ± 7	White	3 ± 1
Highest rank	Magenta	$\bar{x} = 8$	White	$\bar{x} = 4$
G 1	Green	4 ± 0	Green	4 ± 0
G 2	Magenta	13 ± 7	Yellow	4 ± 0
G I	Magenta	4 ± 1	Red	3 ± 1
G H	Red	5 ± 2.5	Blue	3 ± 1.5
G S	Yellow	10 ± 2	White	5 ± 2
Highest rank	Magenta	$\bar{x} = 7$	Magenta	$\bar{x} = 4$
S 2	White	5 ± 3	Yellow	4 ± 1
S 3	White	9 ± 3	Cyan	3 ± 2
S 4	Cyan	3 ± 3	Yellow	5 ± 3
S 5	Yellow	2 ± 0	Yellow	2 ± 0
S 9	Blue	2 ± 1	Yellow	2 ± 1
S 14	Red	2 ± 0	Magenta	2 ± 0
Highest rank	White	$\bar{x} = 4$	Yellow	$\bar{x} = 3$

Table 1. "Colours" and frequencies that produced the greatest amount of driving in the optic tecta and forebrains of pigeons, gulls and starlings. Mean optimum frequency $\pm$ standard deviation for the two brain regions of each bird is calculated for all colours used. The colour with the highest rank and the mean optimum frequency is listed below each species.



Caption for figures

% Power in electrical activity at flash frequency (2-20Hz) and twice the flash frequency (above). W: unfiltered flash, M, R, Y, G, B, C: with red, yellow, green, blue and cyan filters. Flash at 25cm on left side, recordings made from right or left forebrain (Wulst), right or left optic tectum (Tect) or between tecta (X Tect)



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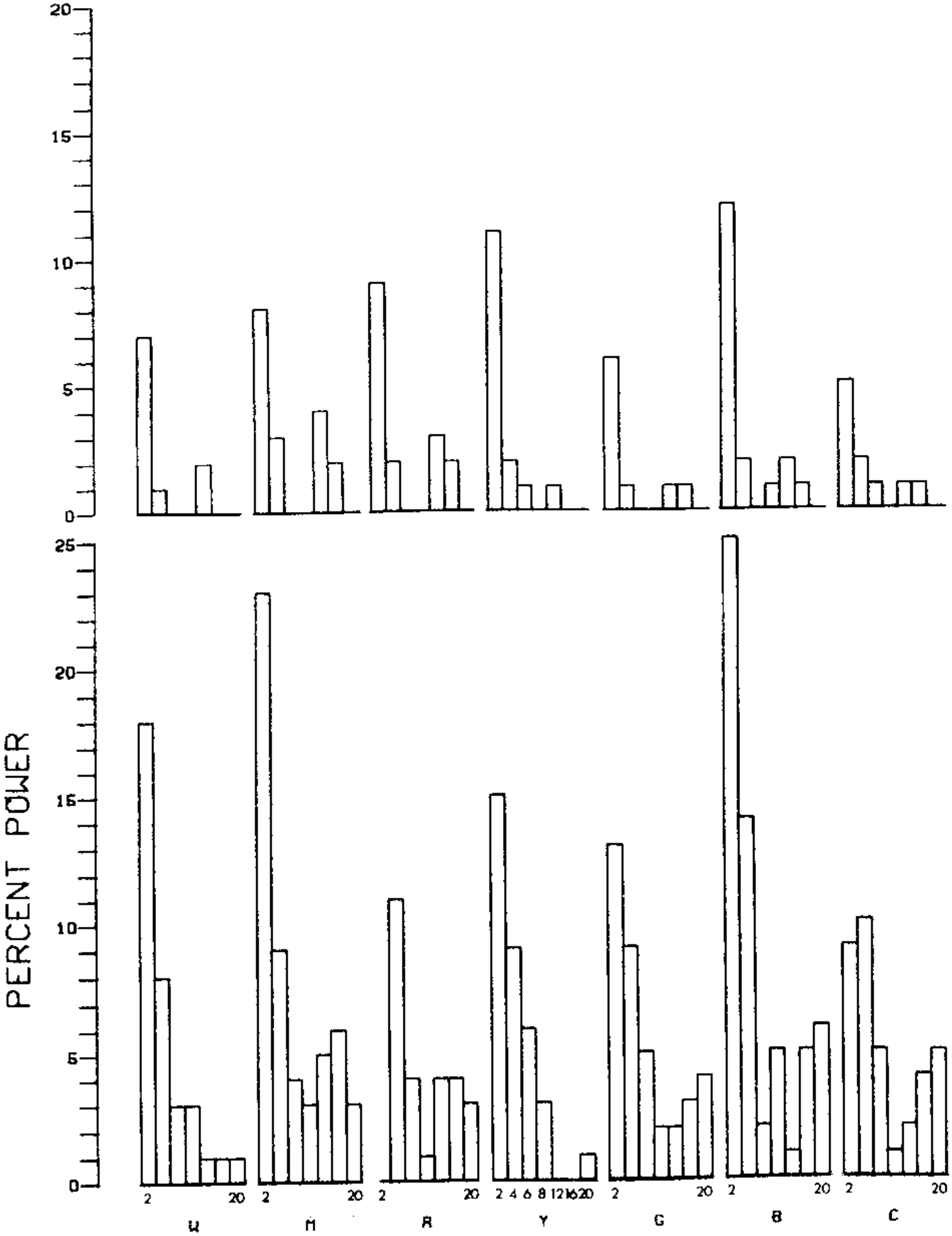
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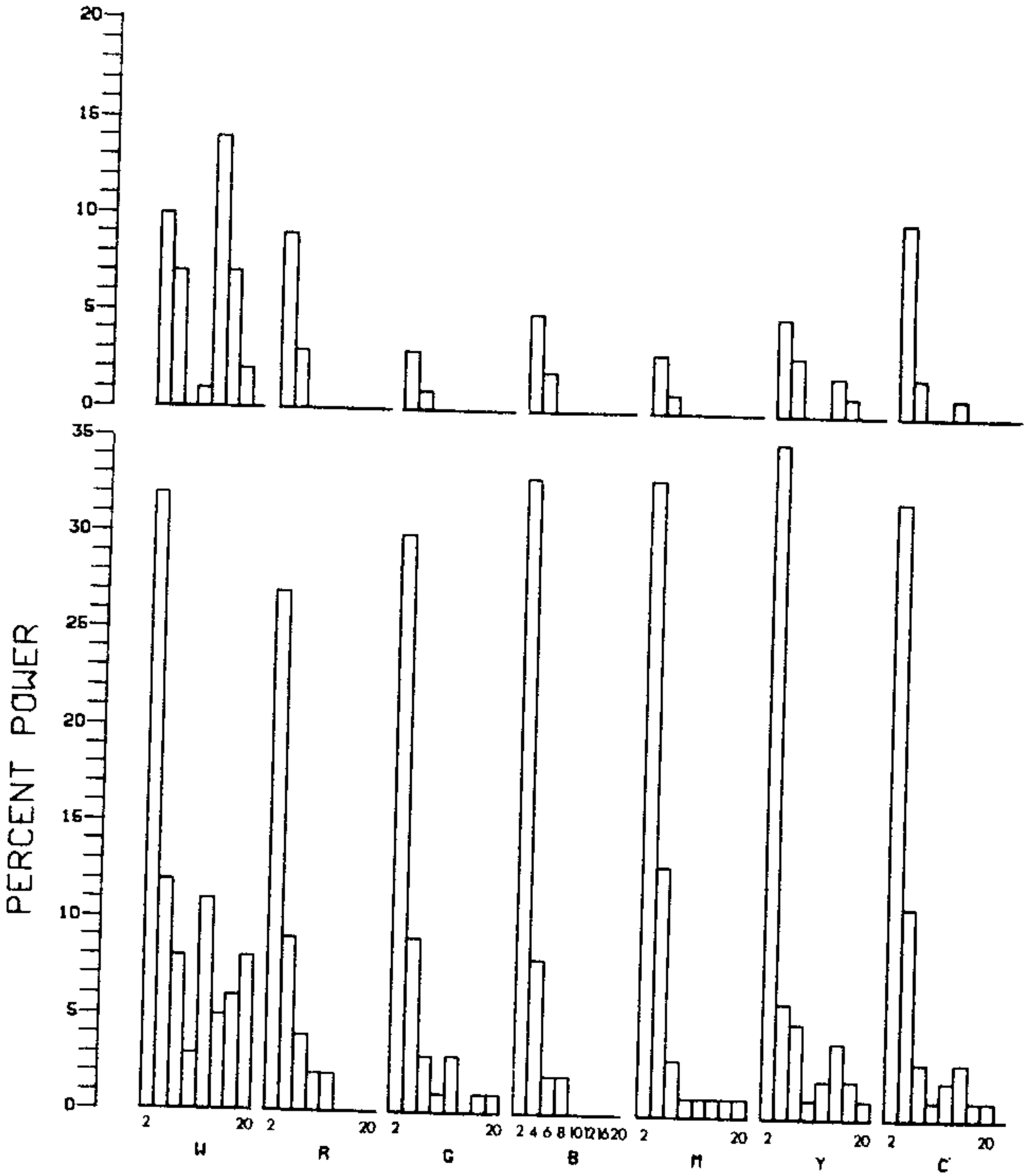
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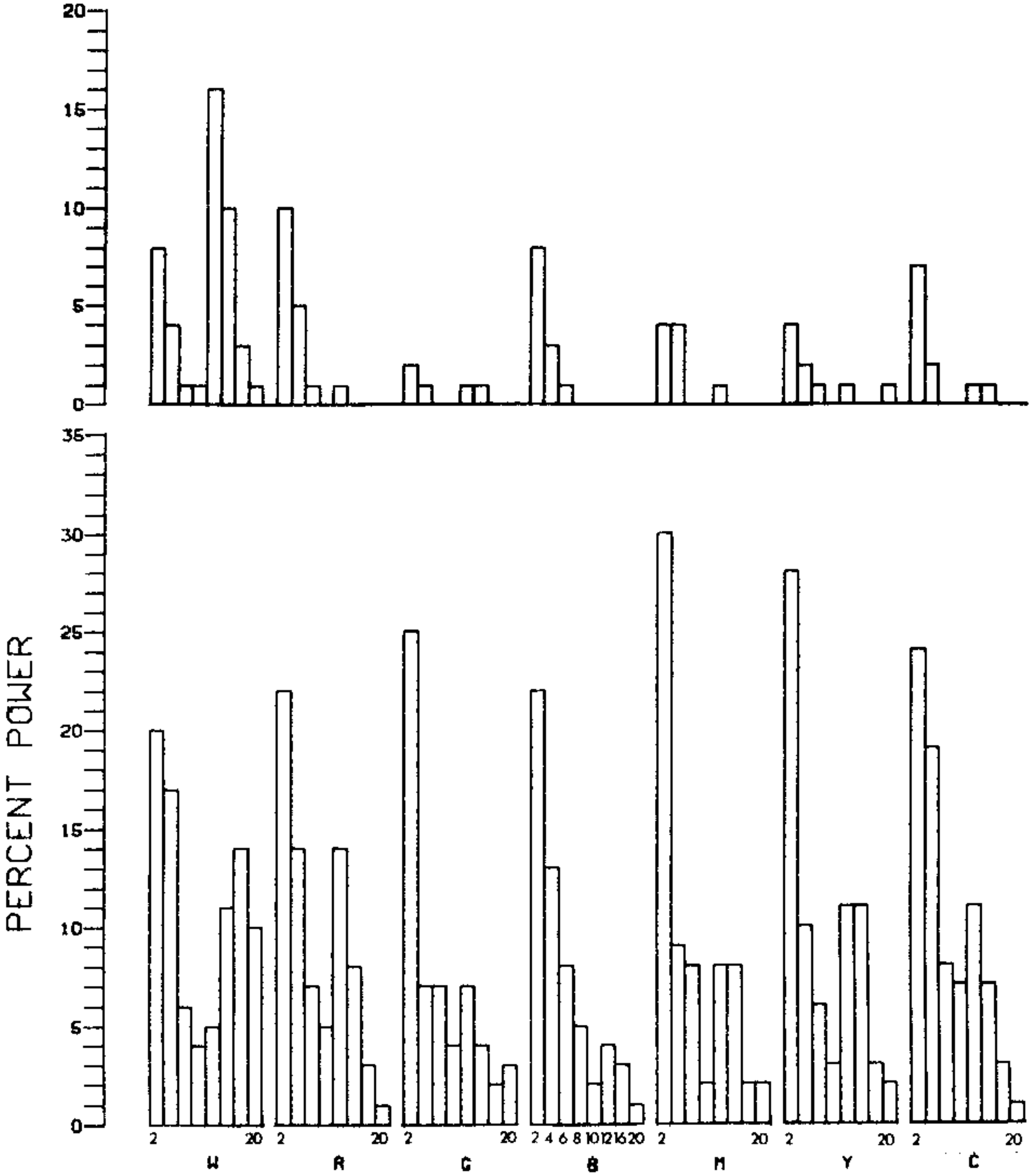
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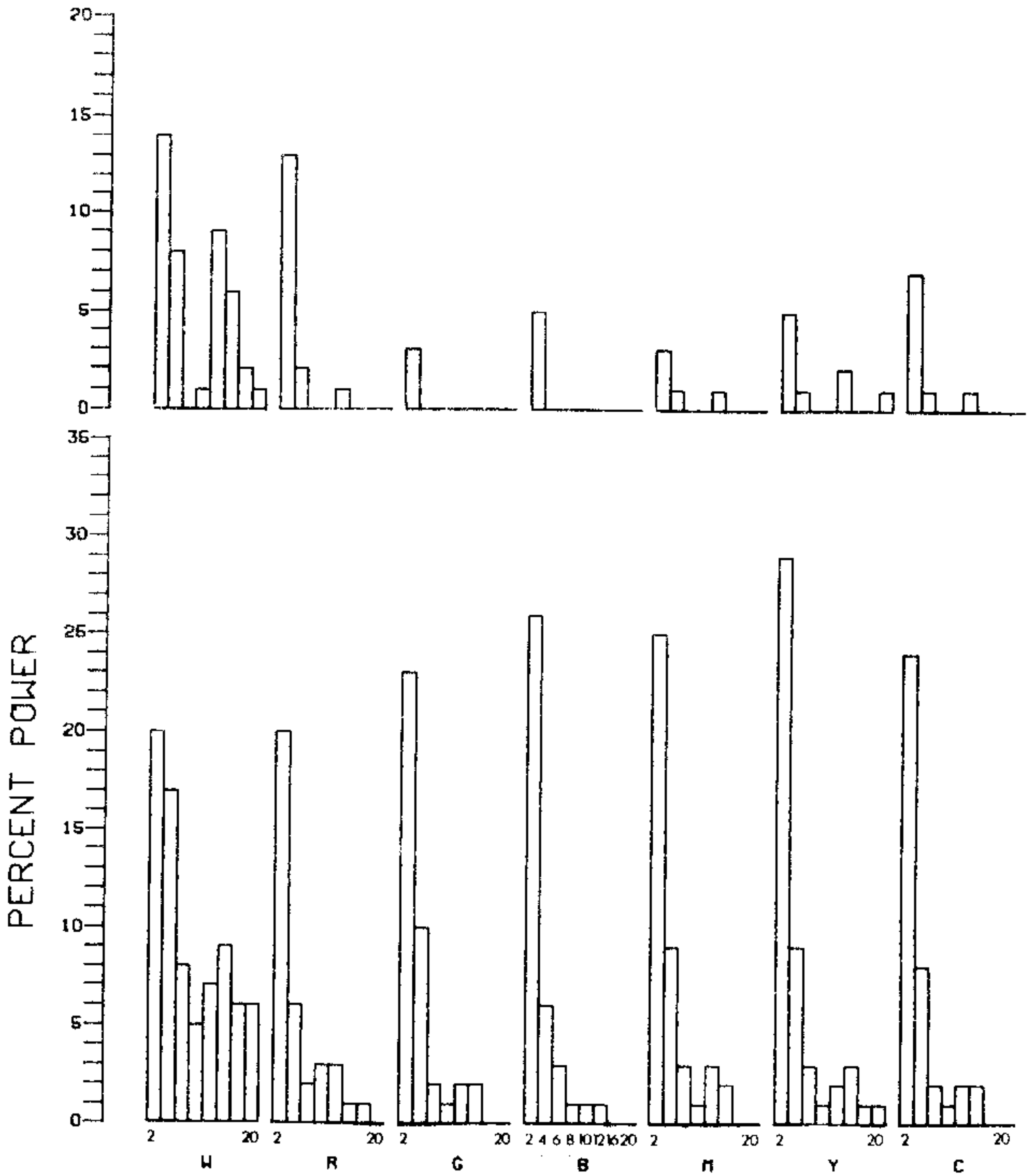

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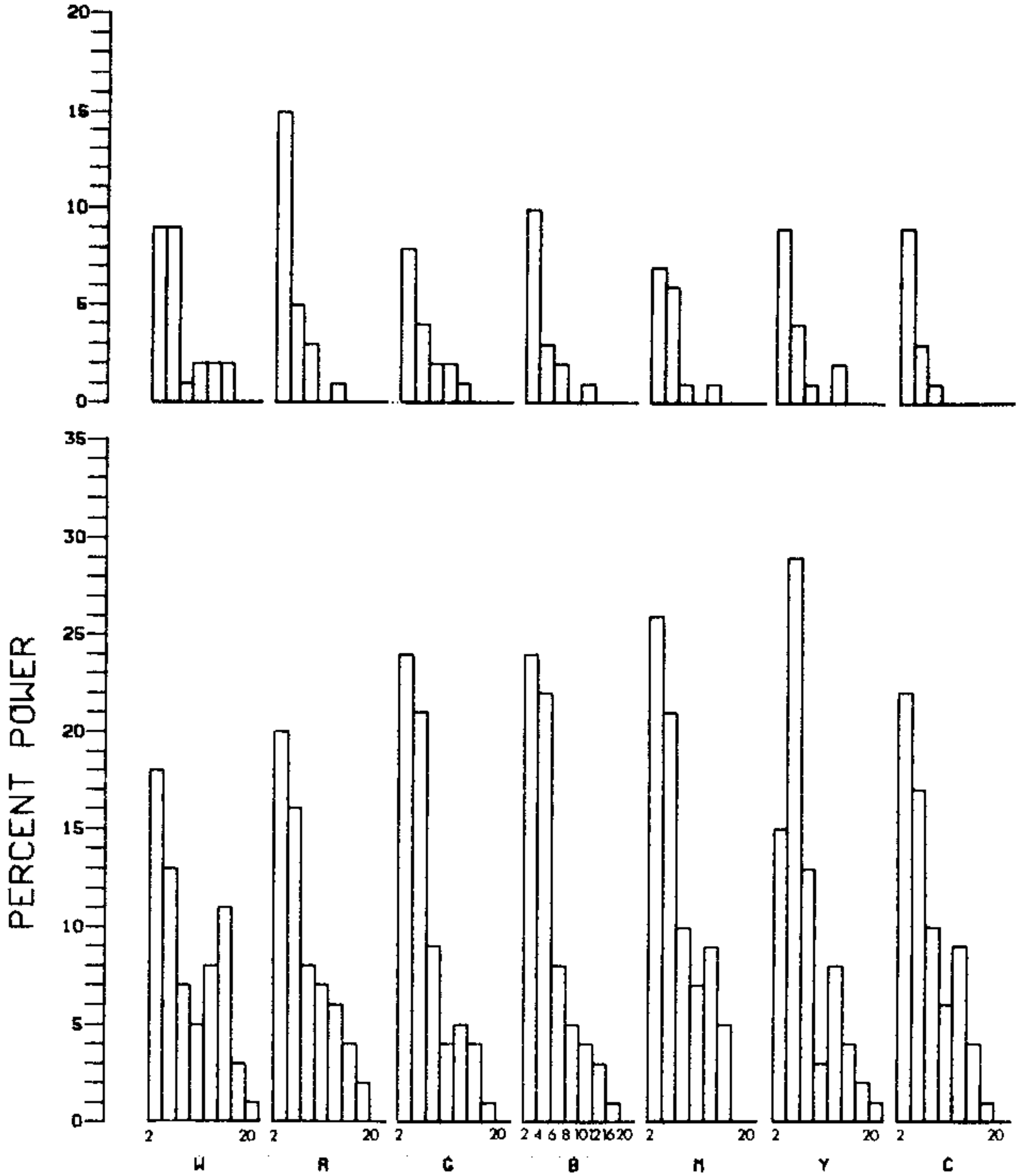

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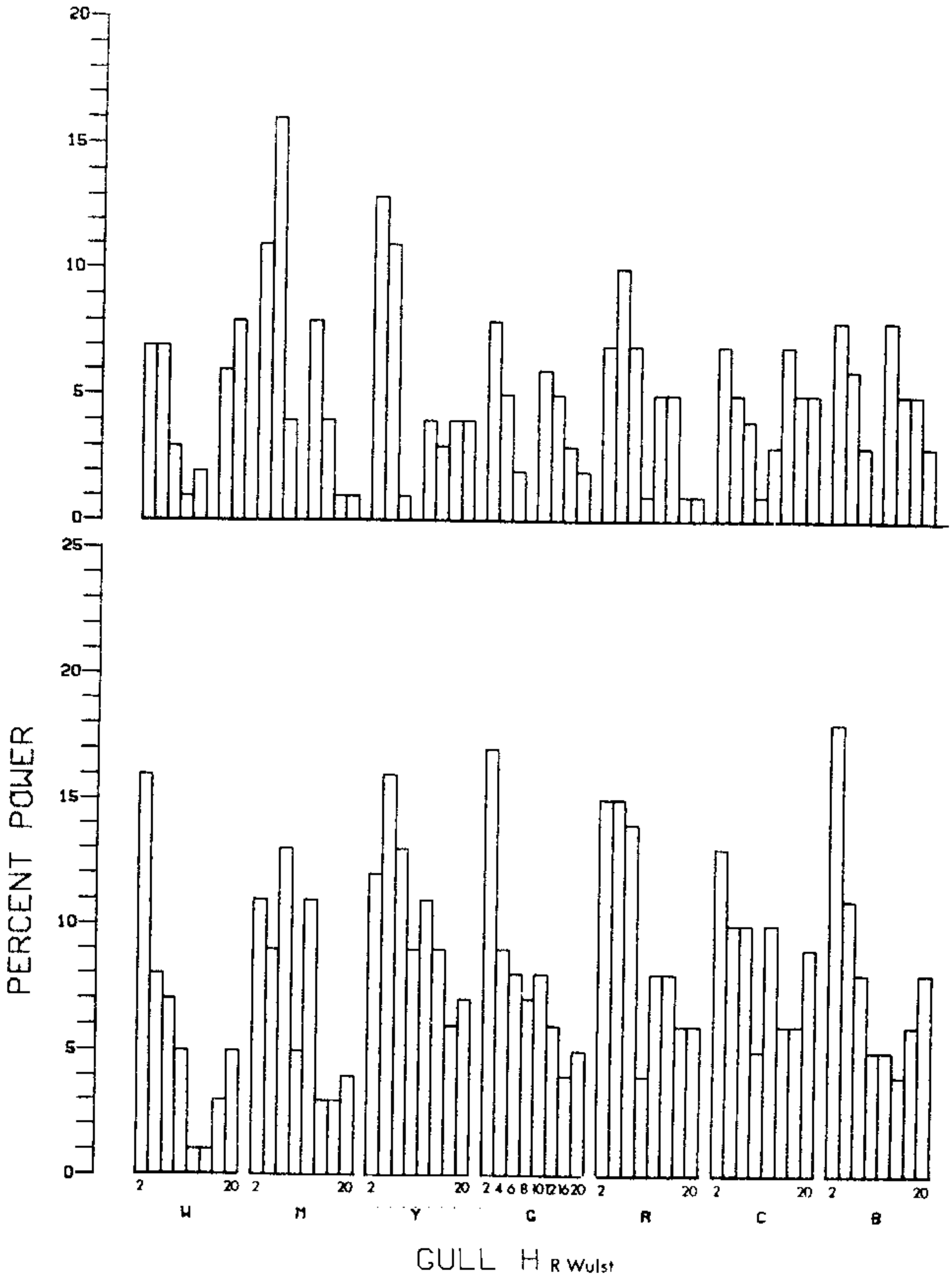

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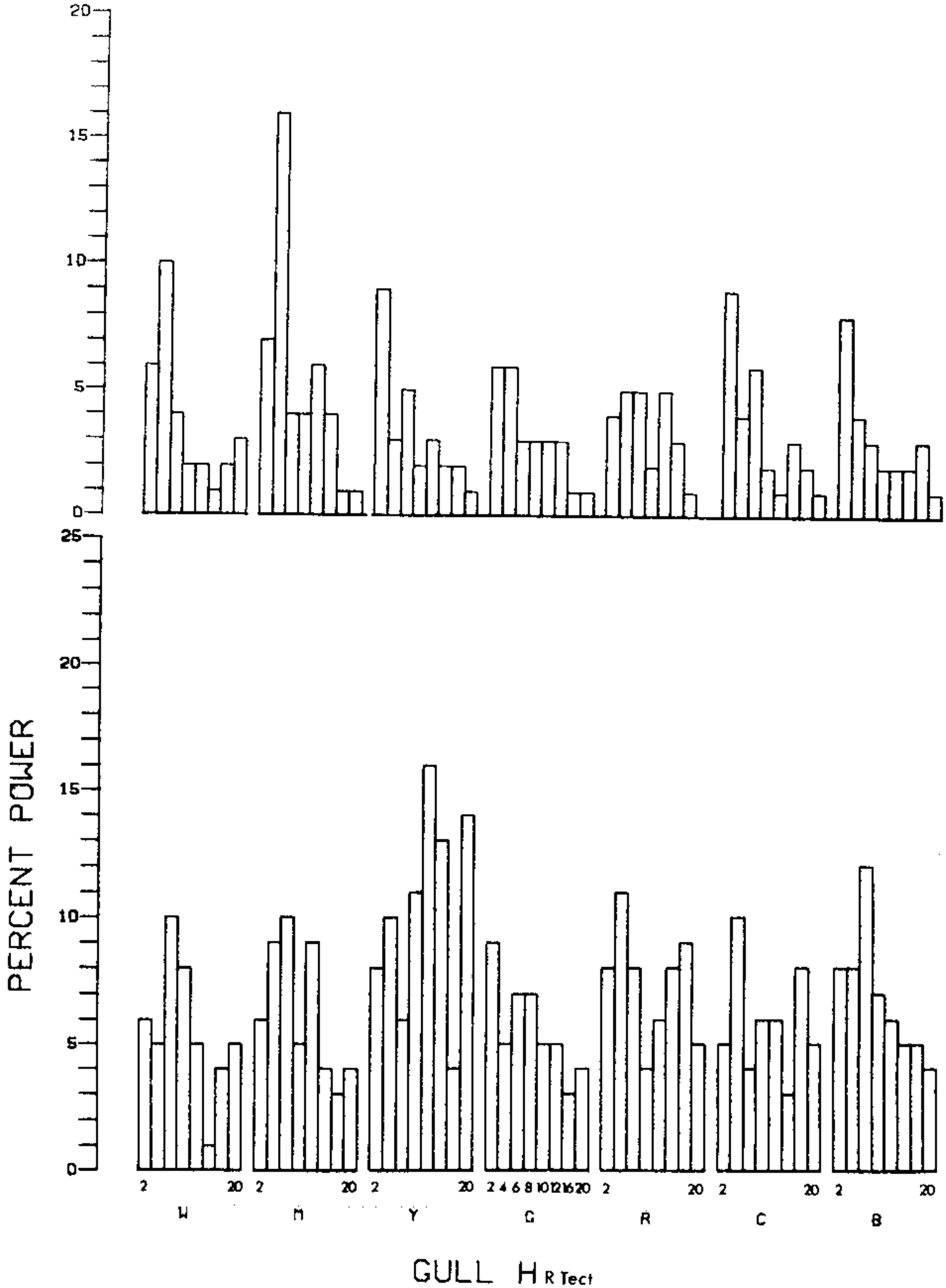

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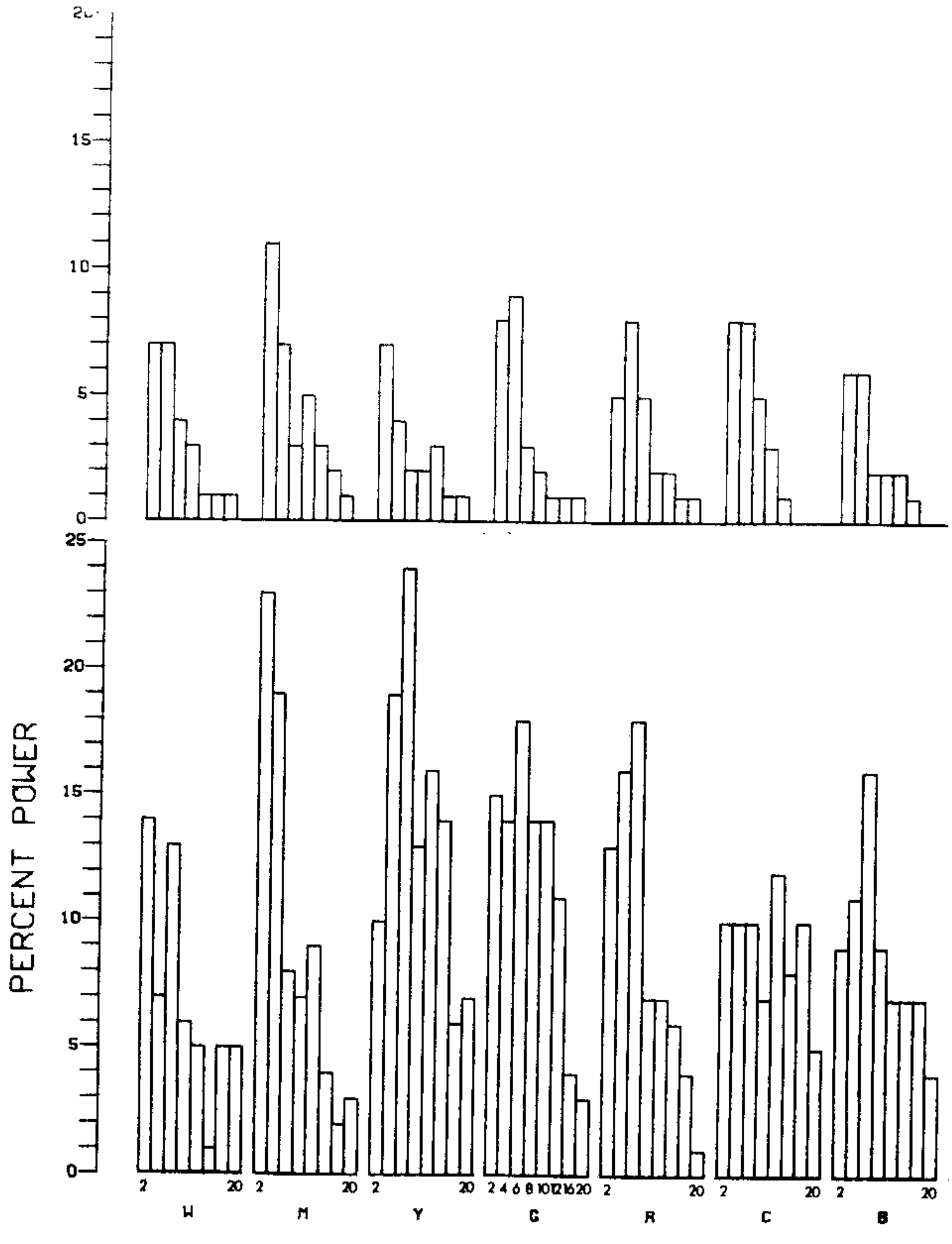

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Conclusions

There is little doubt that under certain conditions lights influence the behaviour of birds, (Imler 1944, Horn 1949, Lustick 1973, Griffin et al. 1974, Larkin et al. 1975).

My preliminary field tests indicate that stationary stroboscopic lights flashed at up to 60Hz have no clear-cut repellent effect on birds, except when accompanied by sound. However, most birds will look at these lights and evidence from other field tests indicates that birds, particularly wildfowl, will evade moving beacons or searchlights.

Electrophysiological results do not at present give any indication of how behaviour may be modified. In these experiments they give some indication of the wavelengths and intensities that can be received and are being processed by the birds.

Of the different wavelengths tested here, it is remarkable that unfiltered strobes (white), despite their greater energy, have less effect than coloured ones (The blue filtered flash, with 1/4 of the energy of the unfiltered one, had a greater effect on two of the birds tested). It is perhaps less surprising that the red end of the spectrum is more effective than the blue, as colour vision in birds is probably mediated largely through yellow and red oil droplets in the retinal cells.

No evidence of "saturation" of the nervous system was found even with the highest flash energy (100 joules at 25cm.) although this flash could not be repeated more often than one flash in 2 sec.

Despite the high variability from bird to bird I conclude that it would be valuable to start field tests with moving red, yellow or magenta strobes. Flash frequencies between 2 and 20Hz could of course be hazardous to any humans subject to epilepsy.

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