Reaction of Lumichrome or 2-Thiolumichrome with Alkylamines

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The reaction of lumichrome (**2**) with alkyl (or allyl)amines such as *n*-butylamine, *n*-hexylamine and allylamine gave 2,3-disubstituted 6,7-dimethylquinoxalines **4a-d**, **5a-d**, **6a-d**, **7a-d** and **8a-d**. Similar reaction of 2-thiolumichrome (**3**) with alkyl (or allyl)amines gave 2,3-disubstituted 6,7-dimethylquinoxalines **6a-c**, **9a-c** and **10a-c**, 2-alkyl (or allyl)amino-6,7-dimethyl-3,4-dihydrobenzo[*g*]pteridine-4-ones **11a-c** and 2,4-dialkyl (or allyl)amino-6,7-dimethylbenzo[*g*]pteridines **12a-c**.

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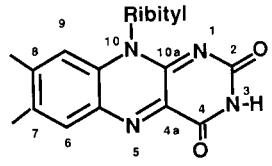
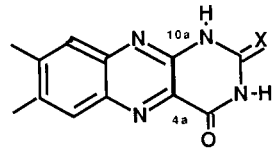
In spite of many reports on the studies of riboflavine (**1**) (vitamin B_2) [1], reactions of lumichrome (**2**) [2] which is the irradiated product of **1** has been little known. We have investigated syntheses and reactions of pyrimidines or fused pyrimidines and found some interesting reactions [3]. We now wish to report the reaction of **2** with alkylamines to give alkylaminoquinoxalines. The reaction of 2-thiolumichrome (**3**) [4] with alkylamines was also examined.

The carbon atoms (C4a and C10a) of lumichrome such as flavines appear to be electron defficient [5]. The initial reaction of **2** with equimolar alkylamines in various solvents did not proceed at all. However, when **2** and large excess of *n*-butylamine was heated without solvent at 78° (boiling point of *n*-butylamine) for 20 hours, 2-allophanoyl-6,7-dimethyl-3-butylaminoquinoxaline (**4b**, 44%) was obtained and unreacted material **2** (20%) was recovered. The reaction under more vigorous conditions (160-170° for 1 hour in a sealed tube) gave **4b** (31%), 3-butylamino-2-(*N'*-butylallophanoyl)-6,7-dimethylquinoxaline (**5b**, 4%), 3-butylamino-6,7-dimethyl-2-quinoxalinecarboxamide (**6b**, 2%), 3-butylamino-6,7-dimethyl-2-quinoxalinecarboxylic acid (**7b**, 30%) and 3-butylamino-6,7-dimethyl-2-quinoxalinecarboxamide (**8b**, 1%). When the reaction temperature was elevated to 220-230°, **5b** (16%), **6b** (35%), **7b** (3%) and **8b** (19%) were isolated and **4b** was just a trace amount.

Chart 1

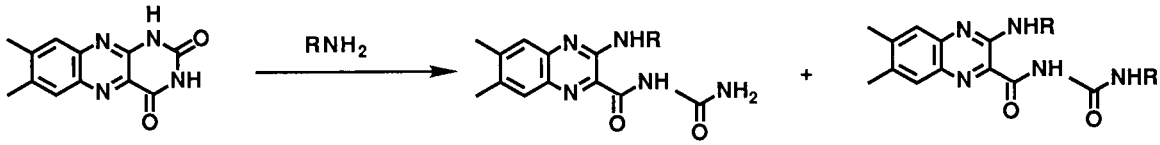


1

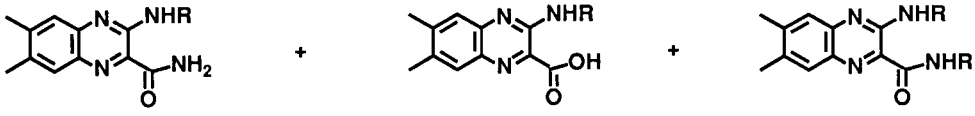


2:X=O
3:X=S

Chart 2



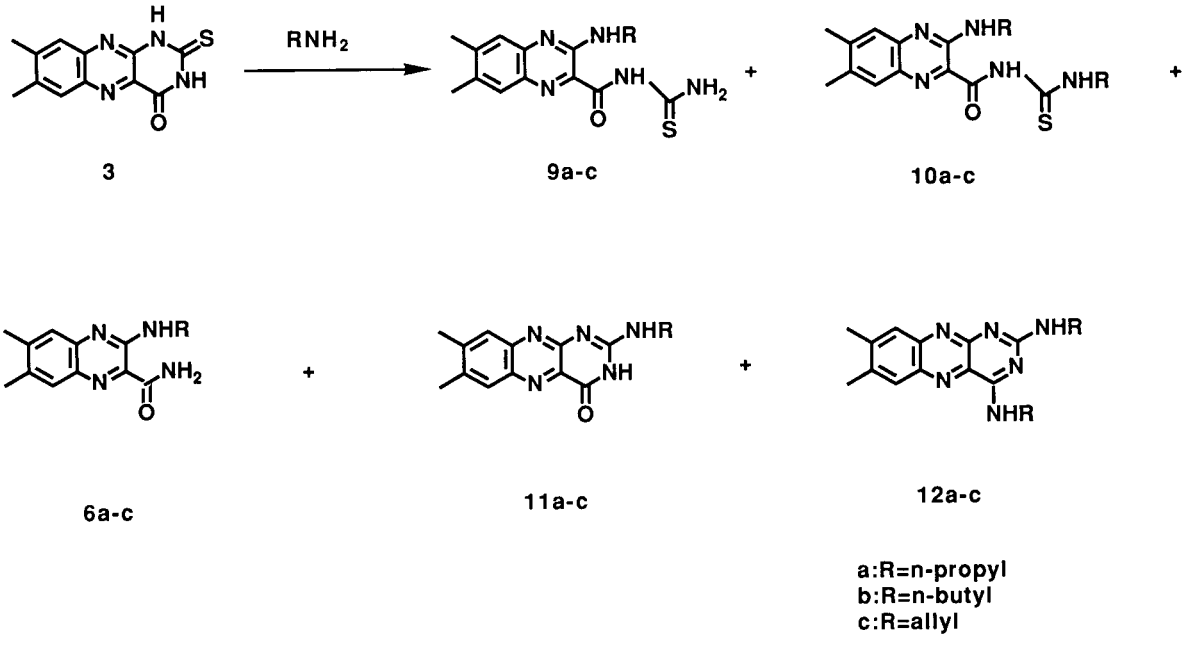
2 4a-d 5a-d



6a-d 7a-d 8a-d

a:n-propyl
b:n-butyl
c:n-hexyl
d:allyl

Chart 3



The ^{1}H-nmr spectrum of **4b** showed signals of butyl group. The molecular ion peak [m/z 315 (M^+)] in the mass spectrum and elemental analysis agreed with the assigned structure. Moreover, we observed that further reaction of **4b** with butylamine gave **5b**, **6b**, **7b** and **8b**. Hydrolysis of **4b** or **5b** with ethanolic potassium hydroxide gave **7b**. The structure of compounds **5b**, **6b**, **7b** and **8b** were established by ^{1}H-nmr and mass spectra. Similarly the reaction of **2** with *n*-propylamine, *n*-hexylamine, or allylamine was carried out in a sealed tube at 160-170° for 1 hour to give **4a,c,d** (10-14%), **5a,c,d** (5-20%), **6a,c,d** (4-14%), **7a,c,d** (22-42%) and **8a,c,d** (2-3%). The reaction of **2** with alkylamines appears to proceed as depicted in Chart 2. Initial nucleophilic attack of an alkylamine to the electron deficient C10a-position gives rise to ring opening of the pyrimidine moiety to give **4**. Further reaction of **4a** with alkylamines gives **5** and **8**. Hydrolysis of **4**, **5**, **6** or **8** will afford **7**. We also tried the reaction of **2** with dimethylamine. However, the reaction did not proceed at all. In this case probably dimethylamine could not attack the electron deficient C10a-position because of steric hindrance.

Similar reaction of **3** with alkyl (or allyl)amines was examined (Chart 3). The reaction of **3** with *n*-propylamine, *n*-butylamine or allylamine at 70° for 9 hours gave 3-alkyl (or allyl)amino-6,7-dimethyl-2-(3-thioallophanoyl)quinoxalines **9a-c** (25-44%) and 2-alkyl (or allyl)amino-6,7-dimethyl-3,4-dihydrobenzo[*g*]pteridin-4-ones **11a-c** (18-40%). Compounds **6a-c**, **10a-c** and **12a-c** were obtained in a small amount (1-3%).

The thus described reaction of lumichrome or thiolumichrome with alkylamines gives a new method of preparation of alkylaminoquinoxalines or alkylaminobenzo[*g*]-pteridines.

EXPERIMENTAL

All melting points were determined with a Yanagimoto micro melting point apparatus and are uncorrected. The infrared spectra were measured with a JASCO IR-810 spectro photometer. Mass spectra were measured with a JEOL JMS-DX 300 spectrometer. Proton nuclear magnetic resonance spectra were recorded with a JEOL JNM-MH-100 or JNM-FX-100 spectrometer using tetramethylsilane as an internal standard. Abbreviations are as follows: s, singlet; d, doublet; q, quartet; br, broad; m, multiplet.

General Procedure for the Reaction of **2** with Alkylamines.

A mixture of **2** (200 mg) and alkylamine (30 ml) was heated at 60° for 1 hour in a sealed vessel made of stainless steel. Excess alkylamine was removed by distillation *in vacuo*. The residue was chromatographed on silica gel eluting with a mixture of chloroform-methanol (30:1). From the first eluate the 3-alkylamino-6,7-dimethyl-2-(*N*-alkyl)quinoxalinecarboxamides **8a-d** were obtained. The second eluate was collected and chromatographed again eluting with a mixture of *n*-hexane-ethyl acetate (3:1) to give 3-alkylamino-6,7-dimethyl-2-quinoxalinecarboxamides **6a-d** and 3-alkylamino-2-(*N'*-alkylallophanoyl)-6,7-dimethylquinoxalines **5a-d**. The third eluate was collected and chromatographed again eluting with a mixture of chloroform-acetone (4:1) to give 3-alkylamino-6,7-dimethyl-2-quinoxalinecarboxylic acids **7a-d** and 3-alkylamino-2-allophanoyl-6,7-dimethylquinoxalines **4a-d**.

2-Allophanoyl-6,7-dimethyl-3-propylaminoquinoxaline (**4a**).

This compound was obtained as fine yellow needles, mp 215-216° (from ethanol) in 10% yield; ^{1}H-nmr (dimethyl sulfoxide-d_6): δ 0.95 (3H, t, J = 7 Hz, $CH_2CH_2CH_3$), 1.65 (2H, sextet, J = 7 Hz, $CH_2CH_2CH_3$), 2.45 (6H, s, $-CH_3$ x 2), 3.30 (2H, q, J = 7 Hz,

NHCH_2CH$_2$CH$_3$), 7.70 (1H, s, aromatic proton), 7.75 (1H, s, aromatic proton), 9.22 (1H, t, J = 7 Hz, C3-NH-propyl), 11.16 (1H, s, -CONHCO-); ir (potassium bromide): 3400, 3330 (NH_2), 3150 (NH), 1705, 1660 (C=O) cm^{-1}; ms: m/z 301 (M^+).

Anal. Calcd. for $C_{15}H_{19}N_5O_2$: C, 59.78; H, 6.36; N, 23.24. Found: C, 60.13; H, 6.51; N, 23.56.

2-Allophanoyl-6,7-dimethyl-3-butylaminoquinoxaline (**4b**).

This compound was obtained as yellow needles, mp 210-212° (from ethanol) in 31% yield; ^{1}H-nmr (dimethyl sulfoxide-d_6): δ 0.98 (3H, t, J = 7 Hz, -CH$_2$CH_3), 1.24-1.76 (4H, m, -(CH_2)$_2$CH$_3$), 2.47 (6H, s, CH$_3$ x 2), 3.49 (2H, q, J = 7 Hz, -NHCH_2-), 7.53 and 7.68 (each 1H, each s, aromatic protons), 8.27 (1H, t, J = 7 Hz, N*H*(CH$_2$)$_3$CH$_3$-), 11.31 (1H, s, -CONHCO-); ir: 3330, 3160 (NH_2), 1710, 1650 (C=O) cm^{-1}; ms: m/z 315 (M^+).

Anal. Calcd. for $C_{16}H_{21}N_5O_2$: C, 60.94; H, 6.71; N, 22.21. Found: C, 60.99; H, 6.41; N, 22.38.

2-Allophanoyl-6,7-dimethyl-3-hexylaminoquinoxaline (**4c**).

This compound was obtained as yellow needles, mp 178-180° (from ethanol) in 14% yield; ^{1}H-nmr (deuteriochloroform): δ 0.91 (3H, t, J = 7 Hz, -(CH$_2$)$_4$CH_3), 1.20-1.82 (8H, m, -(CH_2)$_4$CH$_3$), 2.45 (3H, s, C6- or C7-CH$_3$), 2.46 (3H, s, C7- or C6-CH$_3$), 3.47 (2H, q, J = 7 Hz, -N-CH_2(CH$_2$)$_4$CH$_3$), 7.52 (1H, s, aromatic proton), 7.67 (1H, s, aromatic proton), 8.21 (1H, t, J = 7 Hz, N*H*-CH$_2$-), 11.42 (1H, s, CONHCO-); ir: 3330, 3160 (NH_2), 1700, 1650 (C=O) cm^{-1}; ms: m/z 343 (M^+).

Anal. Calcd. for $C_{18}H_{25}N_5O_2$: C, 62.95; H, 7.34; N, 20.39. Found: C, 62.77; H, 7.03; N, 20.22.

2-Allophanoyl-6,7-dimethyl-3-allylaminoquinoxaline (**4d**).

This compound was obtained as yellow needles, mp 220-221° (from ethanol) in 10% yield; ^{1}H-nmr (deuteriochloroform-dimethyl sulfoxide-d_6): δ 2.50 (6H, s, CH$_3$ x 2), 4.13 (2H, dd, J = 6, 6 Hz, -NHCH_2-), 5.23 (1H, dd, J = 1.5, 6 Hz, *cis* *H*-CH=CH-CH$_2$-), 5.35 (1H, dd, J = 1.5, 12 Hz, *trans* *H*-CH=CH-CH$_2$-), 6.00 (1H, m, CH$_2$=C*H*CH$_2$-), 7.57 (1H, s, aromatic proton), 7.73 (1H, s, aromatic proton), 8.67 (1H, t, J = 6 Hz, N*H*- CH$_2$-), 11.13 (1H, s, CONHCO-); ir: 3330, 3160 (NH_2), 1700, 1655 (C=O) cm^{-1}; ms: m/z 299 (M^+).

Anal. Calcd. for $C_{15}H_{17}N_5O_2$: C, 60.19; H, 5.72; N, 23.40. Found: C, 60.23; H, 5.60; N, 23.58.

3-Propylamino-2-(*N'*-propylallophanoyl)-6,7-dimethylquinoxaline (**5a**).

This compound was obtained as yellow needles, mp 132-133° (from ethanol) in 20% yield; ^{1}H-nmr (deuteriochloroform): δ 1.00 and 1.04 (each 3H, each t, J = 7 Hz, -CH$_2$CH_3 x 2), 1.69 and 1.70 (each 2H, each sextet, J = 7 Hz, -CH_2CH$_3$ x 2), 2.45 (3H, s, -CH$_3$), 2.48 (3H, s, -CH$_3$), 3.44 and 3.45 (each 2H, m, -NH-CH_2 x 2), 7.46 (1H, s, aromatic proton), 7.65 (1H, s, aromatic proton), 8.23 (1H, t, J = 7 Hz, -N*H*CH$_2$-), 9.48 (1H, br, -CON*H*CH$_2$-), 11.27 (1H, s, -CONHCO-); ir: 3390, 3300, 3240 (NH), 1690, 1650 (C=O) cm^{-1}; ms: m/z 343 (M^+).

Anal. Calcd. for $C_{18}H_{25}N_5O_2$: C, 62.95; H, 7.34; N, 20.39. Found: C, 62.83; H, 7.03; N, 20.33.

3-Butylamino-2-(*N'*-butylallophanoyl)-6,7-dimethylquinoxaline (**5b**).

This compound was obtained as yellow needles, mp 123-129° (from ethanol) in 4% yield; ^{1}H-nmr (deuteriochloroform): δ 0.97 and 0.99 (each 3H, t, J = 7 Hz, -(CH$_2$)$_3$CH_3 x 2), 1.25-1.85 (8H, m, -CH$_2$(CH_2)$_2$CH$_3$ x 2), 2.44 and 2.47 (each 3H, s, C6- and C7-CH$_3$), 3.44 and 3.46 (each 2H, q, J = 7 Hz, -NH-CH_2-(CH$_2$)$_2$CH$_3$ x 2), 7.47 and 7.65 (each 1H, s, aromatic protons), 8.20 (1H, t, J = 7 Hz, C3-NH), 9.46 (1H, br, -CON*H*CH$_2$-), 11.23 (1H, s, -CONHCO-); ir: 3390, 3260 (NH), 1695, 1660 (C=O) cm^{-1}; ms: m/z 371 (M^+).

Anal. Calcd. for $C_{20}H_{29}N_5O_2$: C, 64.67; H, 7.87; N, 18.85. Found: C, 64.35; H, 7.82; N, 18.69.

3-Hexylamino-2-(*N'*-hexylallophanoyl)-6,7-dimethylquinoxaline (**5c**).

This compound was obtained as yellow needles, mp 102-103° (from ethanol) in 12% yield; ^{1}H-nmr (deuteriochloroform): δ 0.92 and 0.93 (each 3H, t, J = 7 Hz, -(CH$_2$)$_5$CH_3 x 2), 1.20-1.85 (16H, m, -NCH$_2$(CH_2)$_4$CH$_3$ x 2), 2.47 and 2.50 (each 3H, s, C6- and C7-CH$_3$ x 2), 3.49 and 3.50 (each 2H, q, J = 7 Hz, -NHCH_2-(CH$_2$)$_4$-CH$_3$ x 2), 7.51 and 7.70 (each 1H, s, aromatic protons), 8.25 (1H, t, J = 7 Hz, C3-NH), 9.54 (1H, t, -CON*H*CH$_2$-), 11.27 (1H, s, -CONHCO-); ir: 3320, 3260 (NH), 1690, 1955 (C=O) cm^{-1}; ms: m/z 427 (M^+).

Anal. Calcd. for $C_{24}H_{37}N_5O_2$: C, 67.42; H, 8.72; N, 16.38. Found: C, 67.35; H, 8.43; N, 16.43.

3-Allylamino-2-(*N'*-allylallophanoyl)-6,7-dimethylquinoxaline (**5d**).

This compound was obtained as yellow needles, mp 130-131° (from ethanol) in 5% yield; ir: 3330, 3260 (NH), 1690, 1655 (C=O) cm^{-1}; ms: m/z 399 (M^+).

3-Propylamino-6,7-dimethyl-2-quinoxalinecarboxamide (**6a**).

This compound was obtained as yellow scales, mp 197-199° (from acetonitrile) in 14% yield; ^{1}H-nmr (deuteriochloroform): δ 1.05 (3H, t, J = 7 Hz, -CH$_2$CH$_2$CH_3), 1.72 (2H, sextet, J = 7 Hz, CH$_2$CH_2CH$_3$), 2.42 and 2.44 (each 3H, s, C6- and C7-CH$_3$), 3.46 (2H, q, J = 7 Hz, -NH-CH_2CH$_2$CH$_3$), 6.86 (2H, br, -CONH$_2$), 7.39 and 7.58 (each 1H, s, aromatic protons), 8.21 (1H, br, -NH-); ir: 3390, 3320 (NH_2), 3150 (NH), 1645 (C=O) cm^{-1}; ms: m/z 258 (M^+).

Anal. Calcd. for $C_{14}H_{18}N_4O$: C, 65.09; H, 7.02; N, 21.69. Found: C, 65.31; H, 6.91; N, 21.75.

3-Butylamino-6,7-dimethyl-2-quinoxalinecarboxamide (**6b**).

This compound was obtained as yellow scales, mp 169-170° (from acetonitrile) in 2% yield; ^{1}H-nmr (deuteriochloroform): δ 0.90 (3H, t, J = 7 Hz, -(CH$_2$)$_3$CH_3), 1.12-1.74 (4H, m, -CH$_2$-(CH_2)$_2$-CH$_3$), 2.36 (6H, s, C6- and C7-CH$_3$), 3.30 (2H, q, J = 7 Hz, -NHCH_2-), 7.44 and 7.56 (each 1H, s, aromatic protons), 7.62 (2H, br, -CONH$_2$), 8.91 (1H, br, C3-NH-); ir: 3380, 3170 (NH_2, NH), 1660 (C=O) cm^{-1}; ms: m/z 272 (M^+).

Anal. Calcd. for $C_{15}H_{20}N_4O$: C, 66.15; H, 7.40; N, 20.57. Found: C, 65.99; H, 7.32; N, 20.73.

3-Hexylamino-6,7-dimethyl-2-quinoxalinecarboxamide (**6c**).

This compound was obtained as yellow scales, mp 151-153° (from acetonitrile) in 4% yield; ^{1}H-nmr (deuteriochloroform): δ 0.95 (3H, t, J = 7 Hz, -(CH$_2$)$_5$CH_3), 1.18-1.86 (8H, m, -CH$_2$-(CH_2)$_4$-CH$_3$), 2.42 and 2.43 (each 3H, s, C6- and C7-CH$_3$), 3.46 (2H, q, J = 7 Hz, NH-CH_2-), 6.82 (2H, br, -CONH$_2$), 7.38 and 7.56 (each 1H, s, aromatic protons), 8.18 (1H, br, C3-NH-); ir: 3380, 3330 (NH_2), 3160 (NH), 1660 (C=O) cm^{-1}; ms: m/z 300 (M^+).

Anal. Calcd. for $C_{17}H_{24}N_4O$: C, 67.97; H, 8.05; N, 18.65. Found: C, 67.88; H, 8.01; N, 18.61.

3-Allylamino-6,7-dimethyl-2-quinoxalinecarboxamide (**6d**).

This compound was obtained as yellow scales, mp 199-200° (from acetonitrile) in 8% yield; ^{1}H-nmr (deuteriochloroform): δ 2.30 and 2.32 (each 3H, s, C6- and C7-CH_3), 4.02 (2H, dd, J = 5, 5 Hz, NHCH_2-), 5.10 (1H, dd, J = 2, 5 Hz, *cis* CH(*H*)=CHCH$_2$-), 5.22 (1H, dd, J = 1.5, 12 Hz, *trans* CH(*H*)=CHCH$_3$), 5.85 (1H, m, CH$_2$=C*H*CH$_2$-), 6.72 (2H, br, CONH$_2$), 7.28 and 7.46 (each 1H, s, aromatic protons), 8.16 (1H, br, C3-NH-); ir: 3380, 3300 (NH$_2$), 3150 (NH), 1650 (C=O) cm^{-1}.

Anal. Calcd. for $C_{14}H_{16}N_4O$: C, 65.61; H, 6.29; N, 21.86. Found: C, 65.61; H, 6.10; N, 21.87.

3-Propylamino-6,7-dimethyl-2-quinoxalinecarboxylic Acid (**7a**).

This compound was obtained as yellow prisms, mp >300° (from ethanol) in 22% yield; ^{1}H-nmr (deuteriochloroform-dimethyl sulfoxide-d_6): δ 1.02 (3H, t, J = 7 Hz, -(CH$_2$)$_2$CH_3), 1.65 (2H, sextet, J = 7 Hz, -CH$_2$CH_2CH$_3$), 2.38 and 2.40 (each 3H, s, C6- and C7-CH_3), 3.45 (2H, q, J = 7 Hz, -NHCH_2-), 7.09 and 7.75 (each 1H, s, aromatic protons), 7.85 (1H, br, -NH-), 12.75 (1H, br, -COOH); ir: 3280 (NH), 3150 (OH), 1645 (C=O) cm^{-1}; ms: m/z 259 (M$^+$).

3-Butylamino-6,7-dimethyl-2-quinoxalinecarboxylic Acid (**7b**).

This compound was obtained as yellow prisms, mp 208-209° (from ethanol) in 30% yield; ^{1}H-nmr (dimethyl sulfoxide-d_6): δ 0.95 (3H, t, J = 7 Hz, -(CH$_2$)$_3$CH_3), 1.20-1.70 (4H, m, -CH$_2$(CH_2)$_2$CH$_3$), 2.40 and 2.44 (each 3H, each s, C6- and C7-CH_3), 3.30 (2H, q, J = 6 Hz, NHCH_2-), 7.59 and 7.22 (each 1H, s, aromatic protons), 9.30 (1H, t, J = 6 Hz, C3-C*H*CH$_2$); ir: 3280 (NH), 3150 (OH), 1670 (C=O) cm^{-1}; ms: m/z 273 (M$^+$).

3-Hexylamino-6,7-dimethyl-2-quinoxalinecarboxylic Acid (**7c**).

This compound was obtained as yellow prisms, mp 224-225° (from ethanol) in 36% yield; ^{1}H-nmr (deuteriochloroform-deuteriomethanol): δ 0.88 (3H, t, J = 7 Hz, -(CH$_2$)$_5$CH_3), 1.18-1.78 (8H, m, -CH$_2$(CH_2)$_4$CH$_3$), 2.31 and 2.35 (each 3H, each s, C6- and C7-CH_3), 3.52 (2H, q, J = 7 Hz, -NHCH_2-), 7.12 and 7.70 (each 1H, s, aromatic protons), 9.75 (1H, br, C3-NH-); ir: 3280 (NH), 3110 (OH), 1670 (C=O) cm^{-1}; ms: m/z 301 (M$^+$).

Anal. Calcd. for $C_{17}H_{23}N_3O_2$: C, 67.75; H, 7.69; N, 13.94. Found: C, 67.72; H, 7.58; N, 14.04.

3-Allylamino-6,7-dimethyl-2-quinolinecarboxylic Acid (**7d**).

This compound was obtained as yellow prisms, mp 220-222° (from ethanol) in 42% yield; ^{1}H-nmr (deuteriochloroform-deuteriomethanol): δ 2.36 and 2.40 (each 3H, s, C6- and C7-CH_3), 4.02 (2H, dd, J = 5, 5 Hz, -NHCH_2-), 5.19 (1H, dd, J = 1.5, 13 Hz, *cis* *H*CH=CHCH$_2$), 5.34 (1H, dd, J = 1.5, 16 Hz, *trans* HC*H*=CHCH$_2$-), 6.00 (1H, m, H$_2$C=C*H*CH$_2$-), 7.28 and 7.46 (each 1H, s, aromatic protons), 9.62 (1H, br, C3-NH-); ir: 3280 (NH), 3110 (OH), 1665 (C=O) cm^{-1}; ms: m/z 257 (M$^+$).

Anal. Calcd. for $C_{14}H_{15}N_3O_2$: C, 65.36; H, 5.88; N, 16.33. Found: C, 65.28; H, 5.90; N, 16.40.

3-Propylamino-6,7-dimethyl-2-(*N*-propyl)quinoxalinecarboxamide (**8a**).

This compound was obtained as yellow prisms, mp 74-76° (from hexane-benzene) in 3% yield; ^{1}H-nmr (deuteriochloroform): δ 1.02 and 1.05 (each 3H, t, J = 7 Hz, -CH$_2$CH$_2$CH_3 x 2), 1.68 and 1.75 (each 2H, sextet, J = 7 Hz, -CH$_2$CH_2CH$_3$ x 2), 2.37 and 2.40 (each 3H, s, C6- and C7-CH_3), 3.42 and 3.55 (each 2H, q, J = 7 Hz, -NHCH_2 x 2), 7.45 and 7.52 (each 1H, s, aromatic protons), 8.28 (1H, t, J = 7 Hz, C3-N*H*CH$_2$-), 8.81 (1H, br, -CONH-); ir: 3400, 3330 (NH), 1665 (C=O) cm^{-1}; ms: m/z 300 (M$^+$).

Anal. Calcd. for $C_{17}H_{24}N_4O$: C, 67.97; H, 8.05; N, 18.65. Found: C, 68.35; H, 7.99; N, 18.37.

3-Butylamino-6,7-dimethyl-2-(*N*-butyl)quinoxalinecarboxamide (**8b**).

This compound was obtained as yellow oil in 1% yield; ^{1}H-nmr (deuteriochloroform): δ 0.98 (6H, t, J = 7 Hz, -(CH$_2$)$_3$CH_3 x 2), 1.45 and 1.49 (each 2H, sextet, J = 7 Hz, -CH$_2$CH_2CH$_3$ x 2), 1.65 and 1.68 (each 2H, quint, J = 7 Hz, -CH_2CH$_2$CH$_3$ x 2), 2.36 and 2.39 (each 3H, s, C6- and C7-CH_3), 3.45 and 3.55 (each 2H, q, J = 7 Hz, -NHCH_2 x 2), 7.44 and 7.51 (each 1H, s, aromatic protons), 8.25 (1H, t, J = 7 Hz, C3-N*H*CH$_2$-), 8.77 (1H, br, -CONH-); ir: 3400, 3330 (NH), 1665 (C=O) cm^{-1}; ms: m/z 328 (M$^+$).

Anal. Calcd. for $C_{19}H_{28}N_4O$ HCl: C, 62.54; H, 8.01; N, 15.35. Found: C, 62.39; H, 8.40; N, 15.20.

3-Hexylamino-6,7-dimethyl-2-(*N*-hexyl)quinoxalinecarboxamide (**8c**).

This compound was obtained as yellow oil in 3% yield; ^{1}H-nmr (deuteriochloroform): δ 0.95 and 0.96 (each 3H, t, J = 7 Hz, (CH$_2$)$_5$CH_3 x 2), 1.15-1.18 (16H, m, -CH$_2$(CH_2)$_4$CH$_3$ x 2), 2.36 and 2.39 (each 3H, s, C6- and C7-CH_3), 3.45 and 3.55 (each 2H, q, J = 7 Hz, -NHCH_2 x 2), 7.44 and 7.51 (each 1H, s, aromatic protons), 8.25 (1H, t, J = 7 Hz, C3-N*H*CH$_2$-), 8.82 (1H, br, -CONH-); ir: 3400, 3330 (NH), 1665 (C=O) cm^{-1}; ms: m/z 384 (M$^+$).

3-Allylamino-6,7-dimethyl-2-(*N*-allyl)quinoxalinecarboxamide (**8d**).

This compound was obtained as yellow prisms, mp 89-90° (from hexane-benzene) in 2% yield; ^{1}H-nmr (deuteriochloroform): δ 2.36 and 2.38 (each 3H, s, C6- and C7-CH_3), 4.18 (4H, m, -NHCH_2 x 2), 5.24 (4H, m, CH_2=CH x 2), 6.00 (2H, m, CH$_2$=C*H* x 2), 7.44 and 7.52 (each 1H, s, aromatic protons), 8.33 (1H, t, J = 5 Hz, C3-NH-), 9.54 (1H, t, J = 5 Hz, -CONH-); ir: 3370, 3300 (NH), 1665 (C=O) cm^{-1}; ms: m/z 296 (M$^+$).

Anal. Calcd. for $C_{17}H_{20}N_4O$: C, 68.90; H, 6.80; N, 18.90. Found: C, 68.66; H, 6.67; N, 18.85.

General Procedure for the Reaction of **3** with Alkylamines.

A mixture of **3** (200 mg), alkylamine (25 ml) and pyridine (25 ml) was heated at 70-75° for 9 hours in a sealed vessel made of stainless steel. Excess alkylamine and pyridine were removed by distillation *in vacuo*. The residue was column chromatographed on silica gel eluting with a mixture of chloroform-methanol (10:1). From the first eluate, 3-alkylamino-6,7-dimethyl-2-(4-alkyl-3-thioallophnoyl)quinoxalines **10a-c** were obtained in 1-2% yield. The second eluate gave 3-alkylamino-6,7-dimethyl-2-(3-thioallophanoyl)quinoxalines **9a-c** in 25-44% yield. The third eluate gave **6a-c** in 1% yield. From the fourth eluate 2-alkylamino-6,7-dimethyl-3,4-dihydrobenzo[*g*]pteridin-4-ones **11a-c** in 18-40% yield. The fifth eluate afforded 2,4-dialkylamino-6,7-dimethylbenzo[*g*]pteridines **12a-c** in 1% yield.

3-Propylamino-6,7-dimethyl-2-(3-thioallophanoyl)quinoxaline (**9a**).

This compound was obtained as yellow needles, mp 219-221°

(from ethanol) in 44% yield; ^{1}H-nmr (deuteriochloroform-dimethyl sulfoxide-d_6): δ 1.04 (3H, t, J = 7 Hz, -$CH_2CH_2CH_3$), 1.73 (2H, sextet, J = 7 Hz, -$CH_2CH_2CH_3$), 2.49 (6H, s, C6- and C7-CH_3), 3.47 (2H, q, J = 7 Hz, -NH-CH_2-), 7.50 and 7.70 (each 1H, s, aromatic protons), 8.44 (1H, t, J = 7 Hz, C3-NH-), 12.52 (1H, s, -CONHCS-); ir: 3380, 3280, 3200, 3150 (NH_2, NH), 1655 (C=O) cm^{-1}; ms: m/z 317 (M^+).

Anal. Calcd. for $C_{15}H_{19}N_5OS$: C, 56.76; H, 6.03; N, 22.06. Found: C, 56.76; H, 5.89; N, 22.09.

3-Butylamino-6,7-dimethyl-2-(3-thioallophanoyl)quinoxaline (**9b**).

This compound was obtained as yellow needles, mp 228-230° (from ethanol) in 25% yield; ^{1}H-nmr (deuteriochloroform): δ 0.99 (3H, t, J = 7 Hz, -$(CH_2)_3CH_3$), 3.53 (2H, q, J = 7 Hz, -NHCH_2-), 7.54 and 7.72 (each 1H, s, aromatic protons), 8.22 (1H, t, J = 7 Hz, C3-NH), 12.73 (1H, br, -CONHCS-); ir: 3280, 3200, 3150 (NH_2, NH), 1655 (C=O) cm^{-1}; ms: m/z 331 (M^+).

Anal. Calcd. for $C_{16}H_{21}N_5OS$: C, 57.98; H, 6.39; N, 21.13. Found: C, 58.41; H, 6.39; N, 20.71.

3-Allylamino-6,7-dimethyl-2-(3-thioallophanoyl)quinoxaline (**9c**).

This compound was obtained as yellow needles, mp 256-258° (from ethanol) in 26% yield; ^{1}H-nmr (deuteriochloroform-dimethyl sulfoxide-d_6): δ 2.49 (6H, s, C6- and C7-CH_3), 4.15 (2H, dd, J = 6, 6 Hz, -NHCH_2-), 5.25 (1H, dd, J = 1.5, 10 Hz, *cis* HCH=CHCH_2-), 5.33 (1H, dd, J = 1.5, 17 Hz, *trans* HCH=CHCH_2-), 5.96 (1H, ddd, J = 6, 10, 17 Hz, CH_2=CHCH_2-), 7.54 and 7.72 (each 1H, s, aromatic protons), 8.44 (1H, t, J = 6 Hz, C3-NHCH_2-), 12.49 (1H, br, -CONHCS-); ir: 3390, 3270 (NH_2), 3130 (NH), 1655 (C=O) cm^{-1}; ms: m/z 315 (M^+).

Anal. Calcd. for $C_{15}H_{17}N_5OS$: C, 57.12; H, 5.43; N, 22.21. Found: C, 56.72; H, 5.47; N, 22.03.

3-Propylamino-6,7-dimethyl-2-(4-propyl-3-thioallophanoyl)quinoxaline (**10a**).

This compound was obtained as yellow needles, mp 181-183° (from ethanol) in 2% yield; ^{1}H-nmr (deuteriochloroform): δ 1.02 and 1.12 (each 3H, t, J = 7 Hz, -$CH_2CH_2CH_3$ x 2), 1.70 and 1.83 (each 2H, sextet, J = 7 Hz, -$CH_2CH_2CH_3$ x 2), 2.48 (6H, s, C6- and C7-CH_3), 3.46 and 3.77 (each 2H, q, J = 7 Hz, -NHCH_2- x 2), 7.39 and 7.66 (each 1H, s, aromatic protons), 8.20 (1H, t, J = 7 Hz, C3-NHCH_2-), 11.53 (1H, br, -CSNHCH_2-), 12.55 (1H, s, -CONHCS-); ir: 3270, 3130 (NH), 1665 (C=O) cm^{-1}; ms: m/z 359 (M^+).

Anal. Calcd. for $C_{18}H_{25}N_5OS$: C, 60.14; H, 7.01; N, 19.48. Found: C, 60.34; H, 6.89; N, 19.30.

3-Butylamino-6,7-dimethyl-2-(4-butyl-3-thioallophanoyl)quinoxaline (**10b**).

This compound was obtained as yellow needles, mp 200-202° (from ethanol) in 2% yield; ir: 3390, 3160 (NH), 1670 (C=O) cm^{-1}; ms: m/z 387 (M^+).

Anal. Calcd. for $C_{20}H_{29}N_5OS$: C, 61.99; H, 7.54; N, 18.07. Found: C, 61.91; H, 7.53; N, 18.09.

3-Allylamino-6,7-dimethyl-2-(4-allyl-3-thioallophanoyl)quinoxaline (**10c**).

This compound was obtained as yellow needles, mp 155-157° (from ethanol) in 1% yield; ir: 3380, 3170 (NH), 1660 (C=O) cm^{-1}; ms: m/z 355 (M^+).

Anal. Calcd. for $C_{18}H_{21}N_5OS$: C, 60.82; H, 5.95; N, 19.70. Found: C, 60.53; H, 5.94; N, 19.67.

2-Propylamino-6,7-dimethyl-3,4-dihydrobenzo[*g*]pteridin-4-one (**11a**).

This compound was obtained as yellow prisms, mp >300° (from ethanol) in 18% yield; ^{1}H-nmr (deuteriochloroform-deuteriomethanol): δ 1.02 (3H, t, J = 7 Hz, -$CH_2CH_2CH_3$), 1.79 (2H, sextet, J = 7 Hz, -$CH_2CH_2CH_3$), 2.46 (6H, s, C6- and C7-CH_3), 3.60 (2H, t, J = 7 Hz, -NH-CH_2-), 7.70 and 7.92 (each 1H, s, aromatic protons); ir: 3420, 3230 (NH), 1705 (C=O) cm^{-1}; ms: m/z 283 (M^+).

2-Butylamino-6,7-dimethyl-3,4-dihydrobenzo[*g*]pteridin-4-one (**11b**).

This compound was obtained as yellow prisms, mp 295-298° (from ethanol) in 40% yield; ^{1}H-nmr (deuteriochloroform-deuteriomethanol): δ 1.00 (3H, t, J = 7 Hz, -$(CH_2)_3CH_3$), 1.28-1.79 (4H, m, J = 7 Hz, -$CH_2(CH_2)_2CH_3$), 2.46 (6H, s, C6- and C7-CH_3), 3.60 (2H, q, J = 7 Hz, -NHCH_2-), 7.70 and 7.91 (each 1H, s, aromatic protons); ir: 3430, 3240 (NH), 1695 (C=O) cm^{-1}; ms: m/z 297 (M^+).

2-Allylamino-6,7-dimethyl-3,4-dihydrobenzo[*g*]pteridin-4-one (**11c**).

This compound was obtained as yellow prisms, mp 284-286° (from ethanol) in 21% yield; ^{1}H-nmr (deuteriochloroform-dimethyl sulfoxide-d_6): δ 2.44 and 2.49 (each 3H, s, C6- and C7-CH_3), 4.28 (2H, dd, J = 6, 6 Hz, -NHCH_2-), 5.21 (1H, dd, J = 1.5, 10 Hz, *cis* HCH=CHCH_2-), 5.34 (1H, dd, J = 1.5, 15 Hz, *trans* HCH=CH-CH_2-), 6.00 (1H, m, CH_2=CHCH_2-), 6.95 (1H, br, NH), 7.57 and 7.77 (each 1H, s, aromatic protons); ir: 3420, 3270 (NH), 1705 (C=O) cm^{-1}; ms: m/z 281 (M^+).

2,4-Dipropylamino-6,7-dimethylbenzo[*g*]pteridine (**12a**).

This compound was obtained as yellow prisms, mp 189-190° (from benzene-hexane) in 1% yield; ^{1}H-nmr (deuteriochloroform): δ 1.02 and 1.06 (each 3H, t, J = 7 Hz, -$CH_2CH_2CH_3$ x 2), 1.70 and 1.78 (each 2H, sextet, J = 7 Hz, -$CH_2CH_2CH_3$ x 2), 2.45 and 2.46 (each 3H, s, C6- and C7-CH_3), 4.58 (4H, q, J = 7 Hz, -NHCH_2- x 2), 5.32 (1H, br, C4-NH-), 7.20 (1H, br, C2-NH-), 7.68 and 7.74 (each 1H, s, aromatic protons); ir: 3380, 3220 (NH) cm^{-1}; ms: m/z 324 (M^+).

Anal. Calcd. for $C_{18}H_{24}N_6$: C, 66.64; H, 7.46; N, 25.90. Found: C, 66.25; H, 7.41; N, 25.80.

2,4-Dibutylamino-6,7-dimethylbenzo[*g*]pteridine (**12b**).

This compound was obtained as yellow prisms, mp 215-217° (from benzene-hexane) in 1% yield; ^{1}H-nmr (deuteriochloroform): δ 0.97 and 1.01 (each 3H, t, J = 7 Hz, -$(CH_2)_3CH_3$ x 2), 1.30-1.76 (8H, m, -$CH_2(CH_2)_2CH_3$ x 2), 2.46 (6H, C6- and C7-CH_3), 4.62 (4H, q, J = 7 Hz, -NHCH_2 x 2), 5.24 (1H, br, C4-NH-), 7.15 (1H, br, C2-NH-), 7.69 and 7.72 (each 1H, s, aromatic protons); ir: 3380, 3220 (NH) cm^{-1}; ms: m/z 352 (M^+).

Anal. Calcd. for $C_{20}H_{28}N_6$: C, 68.15; H, 8.01; N, 23.84. Found: C, 67.97; H, 7.67; N, 23.77.

2,4-Diallylamino-6,7-dimethyl-6,7-dimethylbenzo[*g*]pteridine (**12c**).

This compound was obtained as yellow prisms, mp 218-220° (from benzene-hexane) in 1% yield; ^{1}H-nmr (deuteriochloroform): δ 2.47 and 2.49 (each 3H, s, C6- and C7-CH_3), 4.27 (4H, m, -NH-CH_2- x 2), 5.25 (5H, m, -CH_2=CH- x 2 and C4-NH-), 6.00 (2H,

m, $CH_2=CH-$ x 2), 7.32 (1H, br, C2-NH-), 7.70 and 7.76 (each 1H, s, aromatic protons); ir: 3390, 3230 (NH) cm^{-1}; ms: m/z 320 (M^+).

Anal. Calcd. for $C_{18}H_{20}N_6$: C, 67.48; H, 6.29; N, 26.23. Found: C, 67.61; H, 6.21; N, 26.13.

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